Carstens Lake
Manitowoc County, Wisconsin

Comprehensive Management Plan

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1.0 INTRODUCTION AND BACKGROUND

Carstens Lake, located in the Town of Newton, in southeast Manitowoc County, is a 21-acre seepage lake with a maximum depth of 28 feet and a shoreline length of 0.8 miles. The lake drains a watershed of approximately 767 acres and receives groundwater inputs in addition to surface water flow from its watershed (Figure 1). In turn, Carstens Lake is drained by Pine Creek, which discharges to Lake Michigan. The southern shoreline is lined with residential homes, while the northern shoreline remains relatively undeveloped in forested and shrub cover. Year-round public access is provided via a boat launch and 111 feet of public lake frontage along the southern shoreline. Only electric motors are allowed on the lake.

The topography and drainage patterns of the Carstens Lake watershed are largely the result of glaciation, and are characterized by undulating ground moraines, glacial lakes and wetland depressions. The original, pre-European settlement vegetation within the watershed was a forested landscape comprised of swamp conifers in the lowland areas and mixed beech, sugar maple, and basswood dominated forests in the upland areas. The forested landscape was converted to agriculture, following settlement in the mid-1800s, resulting in a significant change in nutrient dynamics within the watershed. Carstens Lake, like many lakes in the heavily agricultural setting of Manitowoc County, is in a eutrophic state, characterized by high levels of nutrient inputs, particularly phosphorus. Carstens lake is small compared to its relatively large, predominantly agricultural watershed of 767 acres, with a watershed to lake area ratio of over 31:1. When considering the agricultural landscape, Carstens Lake is especially vulnerable to excess phosphorus inputs from its drainage basin. Excessive phosphorus has been documented in the lake since the 1970's, ranging from 38 µg/l to as high as 433 µg/l, averaging 150 µg/l (MCLA, 2000). The Wisconsin Department of Natural Resources (WDNR) has classified the lake as a 303(d) Impaired Water due to one or more pollutants and associated water quality impacts.

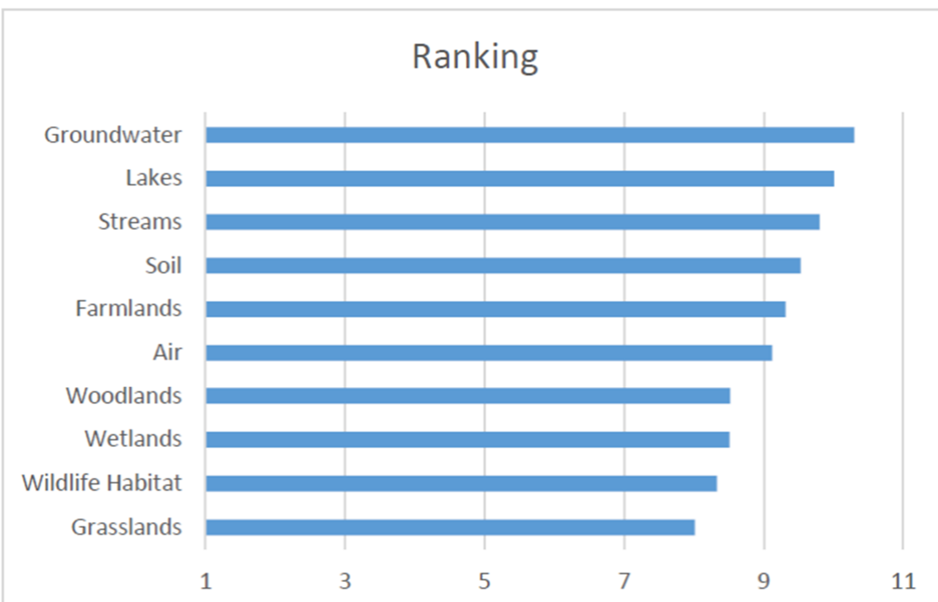
Excess nutrients have resulted in several detrimental effects that have diminished the lake's ecological, recreational, and aesthetic potential. Many groups have been actively concerned and engaged in efforts to improve the health of Carstens Lake over the years. Local residents and lake users, the Manitowoc County Lakes Association, and the WDNR have been involved in funding and conducting studies and lake management planning, which has resulted in a wealth of data for Carstens Lake. Unfortunately, the general trend that emerges from the 1950s onward is of a progressive deterioration in lake water quality, and persistent challenges to maintaining a healthy fishery. The good news is that, because of substantial investments in lake studies and management planning, much is known about the impairments to Carstens Lake and their underlying causes.

In 2000, Manitowoc County Lakes Association (MCLA) developed a lake management plan which identified key sources of phosphorus inputs, and laid out goals for a watershed-scale approach to improving water quality in Carstens Lake. This revised Carstens Lake Management Plan ("the Plan") is being developed to build on previous plans and studies, to recommend on-the-ground conservation measures within the watershed, and provide a framework to implement these measures. The Plan includes additional data collection, modeling of nutrient loading, and will establish target objectives for watershed and water quality improvements for Carstens Lake. The Plan will work to create alliances and partnerships between community members, lake users, landowners, scientists, and agencies to leverage funding and implement strategic conservation practices. The desired outcomes will include benefits to these stakeholders, and success will be built on collaboration among a wide range of local community members.

Stakeholders and Public Participation

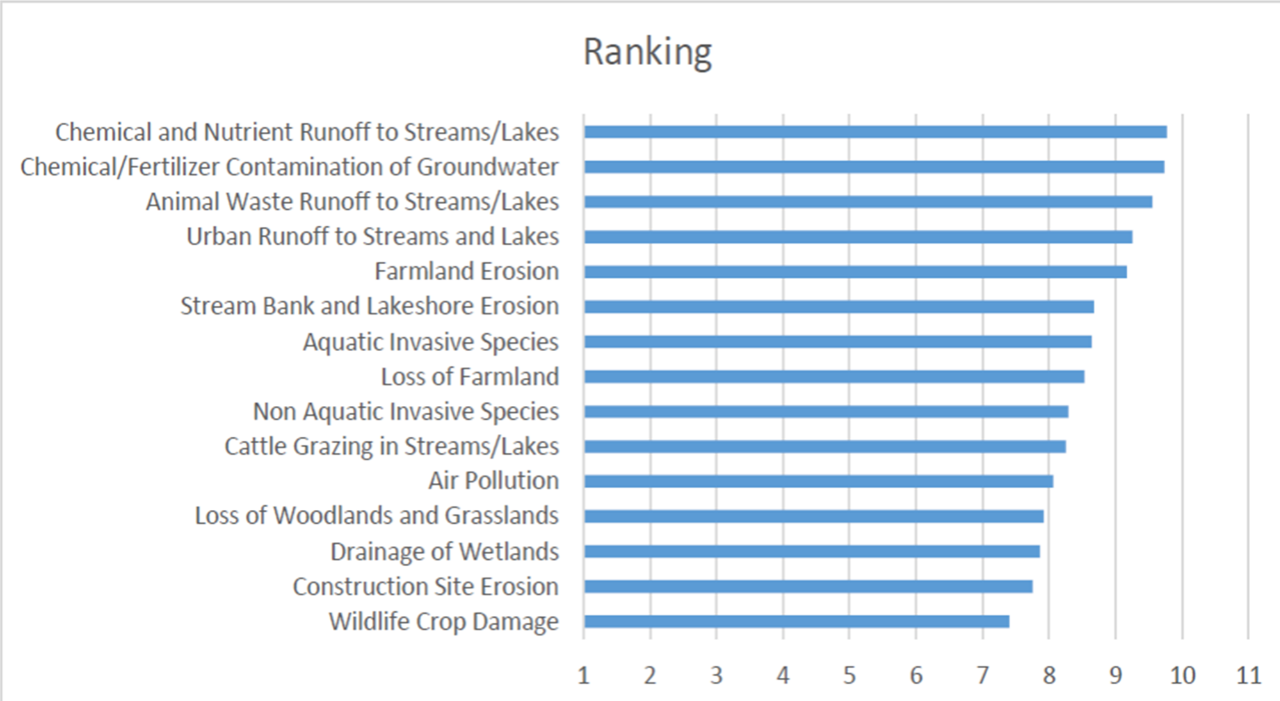
Free participation and integration of stakeholder input was a priority throughout the development of the Plan. In 2014, as part of Manitowoc County's 10-year Land and Water planning process, the county Soil and Water Conservation Department developed a survey for distribution to various members of the community with the purpose of gaining focus on what the public believes the greatest environmental concerns are for the county. Respondents overwhelmingly ranked water quality concerns (groundwater, lakes and streams) as most important, and where resources should be devoted. The following are excerpts from the survey results:

Question 1: Which resources are most important to protect and improve in Manitowoc County?



Resource	Ranking
Groundwater	10.30
Lakes	10.01
Streams	9.80
Soil	9.53
Farmlands	9.31
Air	9.12
Woodlands	8.52
Wetlands	8.51
Wildlife Habitat	8.33
Grasslands	8.01

Question 2: What concerns are most important to devote time to?



Concern	Ranking
Chemical and Nutrient Runoff to Streams/Lakes	9.77
Chemical/Fertilizer Contamination of Groundwater	9.73
Animal Waste Runoff to Streams/Lakes	9.55
Urban Runoff to Streams and Lakes	9.25
Farmland Erosion	9.17
Stream Bank and Lakeshore Erosion	8.67
Aquatic Invasive Species	8.64
Loss of Farmland	8.53
Non Aquatic Invasive Species	8.29
Cattle Grazing in Streams/Lakes	8.25
Air Pollution	8.06
Loss of Woodlands and Grasslands	7.92
Drainage of Wetlands	7.86
Construction Site Erosion	7.75
Wildlife Crop Damage	7.40

According to the survey, the top three concerns were chemical inputs into surface water, chemical inputs to ground water and animal waste contamination of streams/lakes. The survey results highlight the overwhelming importance of water quality to Manitowoc County residents and the importance of developing a lake management plan that addresses water quality concerns throughout the watershed. Additional survey results from the Land and Water Resources Management Plan (2016 – 2025) can be found at the link below:

http://www.co.manitowoc.wi.us/media/2065/2016-lwrm-plan1.pdf

During development of the Plan, stakeholders were informed about the project and its projected outcomes, and were invited to comment on the proposed actions identified for inclusion in the Plan. These are some of the avenues used for public participation:

- Multiple forums (phone calls, emails, etc.)
- Newsletter announcements
- Committee participation in core planning team
- Consultation with leadership interests from user groups and associations
- Public Opinions

Public informational meetings were held to establish citizen awareness of the Plan, its implications, and receive public feedback. Significant public feedback will be considered for Plan amendments. This Plan will be an evolving document, subject to amendments as new issues emerge and we develop appropriate strategies in response.

Local Advisory Committee

A local advisory committee was developed to address environmental concerns of the community. The following groups were represented in the committee:

Lakeshore Natural Resource Partnership – LNRP is the region's leading environmental advocate for the waters of northeast and east central Wisconsin, fostering stewardship in the Lake Michigan Basin and taking action to conserve the region's surface waters and landscapes.

Manitowoc County Lakes Association – MCLA works to protect and enhance the quality of area lakes and watersheds for the benefit of all.

Glacial Lakes Conservancy - The GLC is a community based 501(c)3 non-profit land trust that helps to identify environmentally sensitive areas and works with landowners to protect and conserve their land.

University of Wisconsin-Extension Discovery Farms - Works with Wisconsin farmers to identify the water quality impacts of different farming systems around the state. The program, which is part of UW-Extension, is under the direction of a farmer-led steering committee and takes a real-world approach to finding the most economical solutions to agriculture's environmental challenges.

University of Wisconsin-Manitowoc Lakeshore Water Institute - Serves the lakeshore region with programs to educate and engage with youth, and assists local government leaders in making science-based decisions for watershed planning.

Manitowoc County Soil and Water Conservation Department – MCS&WCD helps provide agricultural and natural resource management throughout Manitowoc County. Their responsibilities include erosion, runoff and sedimentation control and the conservation of soil, water, and related resources in Manitowoc County.

Natural Resource Conservation Service – NRCS is an agency of the United States Department of Agriculture that provides technical assistance to farmers and other landowners with a variety of programs aimed at protecting soil, water, habitats, and other natural resources.

University of Wisconsin Extension - Outreach arm of the University of Wisconsin System. UW-Extension provides statewide access to university resources and research to Wisconsin residents.

Wisconsin Department of Natural Resources- WDNR has a mandate to protect the waters of Wisconsin and works with the Wisconsin Lakes Partnership to promote healthy watersheds and fund watershed planning.

InDepth Agronomy – Private agronomy company offering crop consulting services.

Local Advisory Committee Recommendations and Discussions

Update after meetings

Public Outreach Results

Update after meetings

2.0 PREVIOUS MANAGEMENT ACTIONS

Ecological concerns relating to water quality in Carstens Lake have been persistent over the past 15 – 20 years. Over this period, surveys and studies of the lake have been performed, identifying impairments and establishing the need for improving water quality and the fishery of the lake.

In 1968, the Seven-Mile Silver Creek Watershed project was initiated to address nutrient management within the watershed, which includes Carstens Lake. The Seven-Mile Silver Creek watershed was designated a priority watershed under the Nonpoint Source Pollution Abatement Program in 1984, and was noted for the high level of participation by landowners in the Manitowoc County portion of the watershed (WDNR, 1997).

Fisheries surveys have been occurring in Carstens Lake since 1955, and generally occur every five years, with the last fisheries report completed in 2015. In 1982, the lake was treated with rotenone to remove rough fish species and a fish barrier was placed in Pine Creek to prevent re-entry from Lake Michigan. That same year, a stocking program was initiated by WDNR. Several species were stocked annually between 1982 and 1986, and then sporadically thereafter. In 1997-98 winter fish kills were noted. An aerator was installed in the lake to keep ice open and allow oxygen into the lake to prevent winter kills (MCLA, 2000)

A management plan for the lake was developed in 1978, and common carp and black bullhead were targeted for removal that year. In 2000, a management plan was prepared which detailed follow-up studies and management actions to be implemented within the lake and surrounding watershed.

A feasibility study for alum treatment, a method to remove phosphorus from the lake, was conducted by NES Ecological Services (2003), on behalf of MCLA.

An aquatic plant survey of the lake was completed by Onterra, LLC (Butterfield, et al., 2010) to assess the level of aquatic invasive plant species, and recommendations for aquatic vegetation management were proposed.

The Soil and Water Conservation Department provides administrative or technical support for a variety of Best Management Practices (BMP). The following BMPs have been installed within the Carstens Lake watershed since XXXX:

- NRCS has provided XX EQIP and XX CSP contracts.
- County has approved XX CRP contracts and CREP contracts.
- County has installed XX manure storage facilities, XX barnyard run off control systems, XX miles of grassed waterways; XX wetland restorations; XX miles of buffers; XX conservation easements; XX Vegetated Treatment Areas constructed; and XX acres within a Nutrient Management Plan.

3.0 NATURAL RESOURCE APPRAISALS, OBJECTIVES AND STRATEGY

To achieve water quality improvements within Carstens Lake, and improve habitat and ecological processes across the watershed, a set of objectives and strategies are presented below for each natural resource category.

3.1 Water Quality of the Lake

Carstens Lake has been the subject of numerous studies, beginning in the 1950s, focusing primarily on the sport fishery and water quality within the lake. Focusing on specific aspects or parameters that are important to lake ecology, comparing those values to similar lakes within the same region and historical data from the lake is a useful tool for evaluating water quality and establishing achievable water quality objectives.

Phosphorus, Chlorophyll-*a* and Secchi disk transparency are common water quality parameters evaluated in lakes. Phosphorus is a limiting nutrient that controls the growth of aquatic vegetation, including algae and macrophytes. Monitoring and evaluating concentrations of phosphorus within the lake permits a better understanding of current and potential aquatic plant growth rates.

Chrolophyll-*a* is the green pigment in plants and algae used in photosynthesis. Chlorophyll-*a* concentrations are directly related to the abundance of free-floating algae in the lake, and Chlorophyll-*a* is a useful measurement of the intensity of algal blooms.

Secchi disk transparency is a measurement of water clarity, and is perhaps the most used and easiest to understand and interpret. Furthermore, measuring Secchi disk transparency over long periods of time is one of the best methods of monitoring the health of a lake.

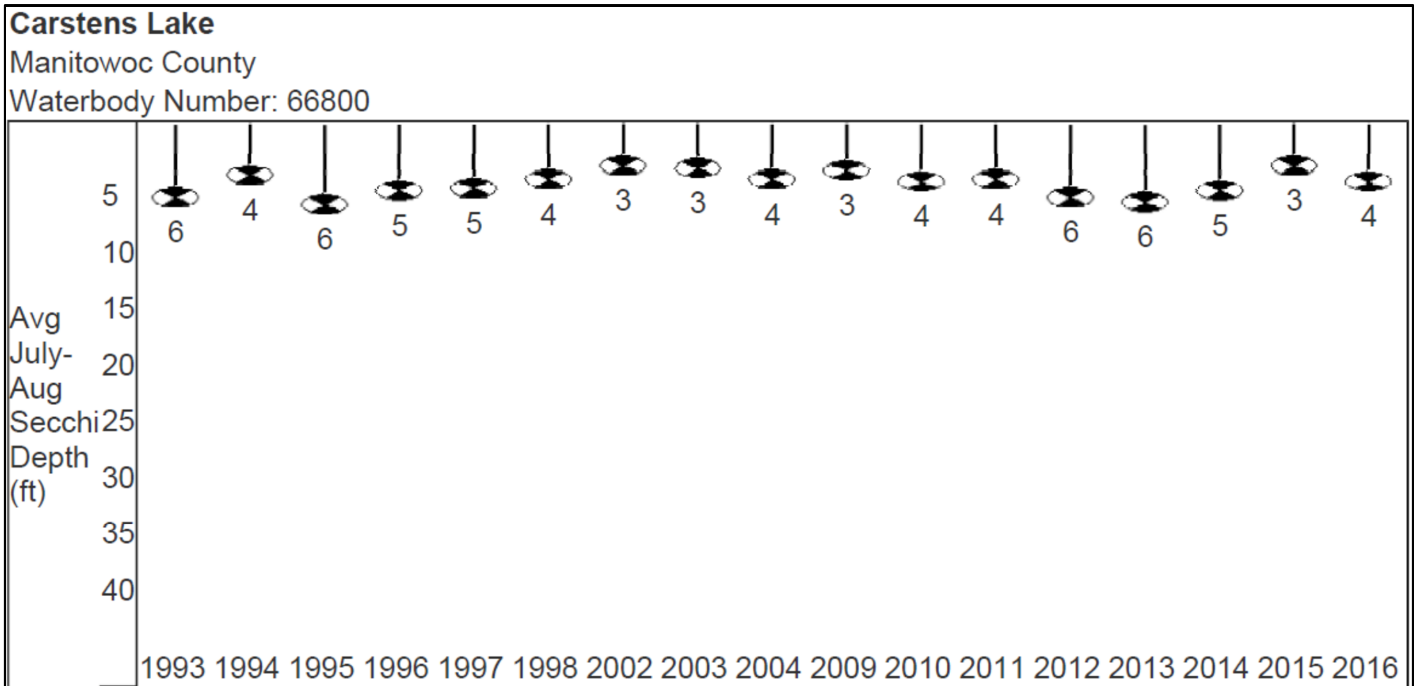
Wisconsin bases its General Condition Assessment for lakes on the Carlson Trophic State Index (TSI). The Carlson TSI is the most commonly used index of lake productivity. It provides separate, but relatively equivalent TSI calculations based on either chlorophyll *a* concentration or Secchi depth. TSI values range from low (less than 30), representing very clear, nutrient-poor lakes, to high (greater than 70) for extremely productive, nutrient-rich lakes. Total phosphorus, chlorophyll-a and water clarity values are directly related to the trophic state of a lake. As nutrients, primarily phosphorus, accumulate within a lake, its productivity increases and the lake progresses through the following three trophic states:

- Oligotrophic (low nourishment and productivity) — Oligotrophic lakes tend to be very clear with low phosphorous levels and low production of biological material.
- Mesotrophic (moderate nourishment and productivity) — Mesotrophic lakes are more fertile with higher phosphorous levels, and moderately clear water. Biological productivity is elevated including fish production.
- Eutrophic (high nourishment and productivity) — Eutrophic lakes are very fertile, supporting high productivity of algae, aquatic plants, and abundant quantities of fish. However, extremely eutrophic (hypertrophic) conditions, often due to excessive phosphorus inputs from agricultural runoff, urban stormwater, or leaking septic systems, lead to a variety of

impairments to lake water quality. Problems can include excessive aquatic vegetation, frequent and severe algae blooms, low oxygenation, winter fish kills, and reduced usability for recreational boating and swimming.

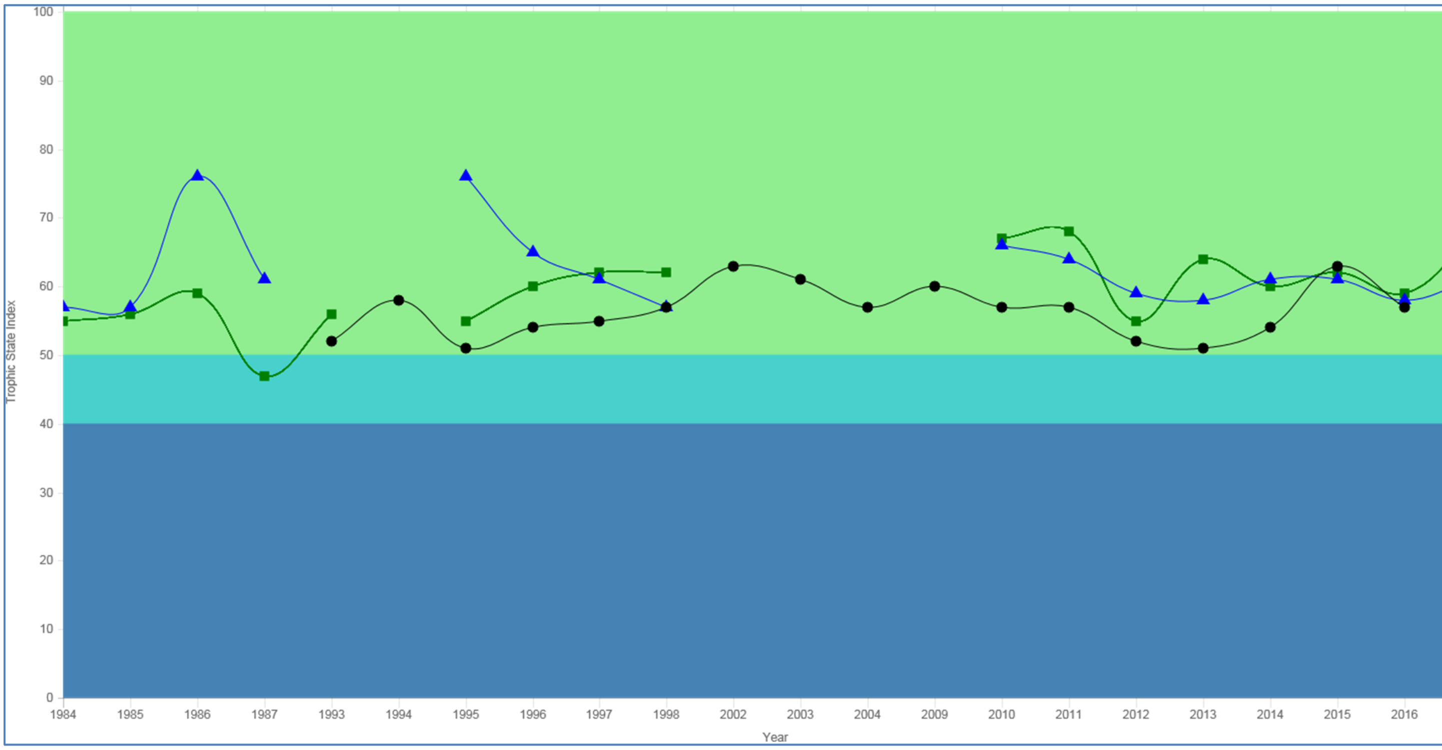
Water quality parameters within Carstens Lake have been monitored annually by volunteers since 1976. Volunteers monitor Secchi disk transparency and collect water samples which are sent to the State Lab of Hygiene to be analyzed. In 2017, water quality parameters were sampled within Carstens Lake during 4 different days in summer 2017. The average summer Chlorophyll-a was 74.7 µg/l (compared to a Southeast Georegion summer average of 25.4 µg/l). The summer Total Phosphorus average was 67.3 µg/l. The overall TSI for Carstens Lake based on 2017 data was 67, suggesting a continued eutrophic state. The average summer trophic state for the last 5 years was 63 (Table 1). Detailed water quality data from 1976 to 2017 can be found on the WDNR Carstens Lake citizen monitoring web site: http://dnr.wi.gov/lakes/CLMN/Station.aspx?id=363036

Figure 2. 1993 – 2016 Secchi disk measurements from Carstens Lake



Past secchi averages in feet (July and August only).

Figure 3. 1984 – 2017 TSI results from Carstens Lake



● Secchi TSI ▲ Total Phosphorus TSI ■ Chlorophyll TSI

Table 1. Trophic Status Index (TSI) thresholds – general assessment of lake Natural Communities.

Condition Level	Shallow			Deep			
	Headwater	Lowland	Seepage	Headwater	Lowland	Seepage	Two-Story
Excellent	< 53	< 53	< 45	< 48	< 47	< 43	< 43
Good	53 – 61	53 – 61	45 – 57	48 – 55	47 – 54	43 – 52	43 – 47
Fair	62 – 70	62 – 70	58 – 70	56 – 62	55 – 62	53 – 62	48 – 52
Poor	≥ 71	≥ 71	≥ 71	≥ 63	≥ 63	$\boxed{\geq 63}$	≥ 53

Prior to European settlement, the Carstens Lake watershed, like most of Manitowoc County, consisted of a largely forested landscape. Even prior to intensive European settlement, the lake was likely already in a naturally eutrophic state, based on modelling of watershed level phosphorus inputs (NES Ecological Services, 2003). After conversion of the watershed to the mostly agricultural landscape of today, phosphorus inputs increased substantially, and the lake approached a hypertrophic state, characterized by high phosphorus levels and algae blooms. The watershed landscape continued to change as farming practices evolved from the 1950s to today. Over that period, the extent of tilled cropland likely gained at the expense of grassy pastureland. Early lake studies from the 1950s describe a lake quite different from the Carstens Lake of today. A 1955 study (Cline, cited in Surendonk, 1999) reported that there were no residences on the lake, and access was limited to a private road on the south end of the lake. There was a boat rental and moderate to light fishing pressure, with largemouth bass, northern pike, bluegill, crappie and perch. Also at that time, the surrounding watershed was described as

50% forest (predominantly American elm) and 50% pasture and cropland. As of 2000, the watershed was reported to be comprised of 61% agriculture, and only 19% woodland (MCLA, 2000). Public access was first obtained in 1958, when the Wisconsin Conservation Department purchased an easement and boat launch, which is located along the southwest shore. By 1964, there were still no permanent residences on the shoreline, but there was one permanently placed trailer. At that time, filamentous algae was abundant, there were heavy free-floating algae blooms, and dense aquatic plants (Surendonk, 1999).

Today, Carstens Lake is characterized by heavy filamentous algae growth and dense aquatic vegetation. Excess plant and algae growth is related to high phosphorus levels, which in turn come from both internal phosphorus cycling and external sources in the watershed. Turbidity is high and water clarity is poor, largely as a result of free-floating algae. In addition, mats of algae and aquatic plants tend to pile up and cover the shorelines, resulting in smelly and unsightly conditions that make swimming in Carstens Lake undesirable. Reported levels of fecal coliform bacteria in tributaries to the lake have also been a serious cause of concern for health and safety for swimming and other recreation on the lake. The bacteria problem may be issuing from failed septic tanks at homes along the lakeshore, as well as possibly from livestock manure, via runoff from barnyards, pasture, or spreading on crop fields (MCLA, 2000). In the past, major manure runoff events in winter have resulted in manure washing onto the lake ice, however a Manitowoc County ordinance is now in place that prohibits spreading on frozen ground.

Phosphorus is a limiting nutrient for algae, thus the amount of phosphorus is a critical driver in controlling lake fertility. Simply put, the more phosphorus entering the lake, the more plant growth, both aquatic macrophytes and algae. Excessive plant/algae growth in turn leads to problems including low oxygen and winterkills, which have resulted in a loss of desirable fish species from the lake (Surendonk, 1999). Many of the strategies in this plan are focused on controlling phosphorus inputs. This is not the only nutrient concern; however, it is currently the most important for water quality protection. A confounding issue is that the phosphorus in the lake bottom sediments will continue to be resuspended into the water column for decades to come.

Objectives for Lake Water Quality

1) Adopt a 10-year phosphorus reduction goal - As detailed in the Manitowoc County Land and Water Resource Management Plan (2016-2025), a 10-year phosphorus reduction goal of 10% by 2026, or 1% annually is recommended.
2) Completion of a TMDL for Manitowoc River or Pine Creek watersheds would help to establish appropriate phosphorus reduction goals to remove the impairments from Carstens Lake and Pine Creek.
3) Maintain water quality functions of all riparian wetlands. Navigation, aesthetic perceptions, and nuisance aquatic plant management also will be supported by the lakes partnership. However, the protection of the lake water quality, through the maintenance of wetland areas will take priority in situations where conflicts occur.

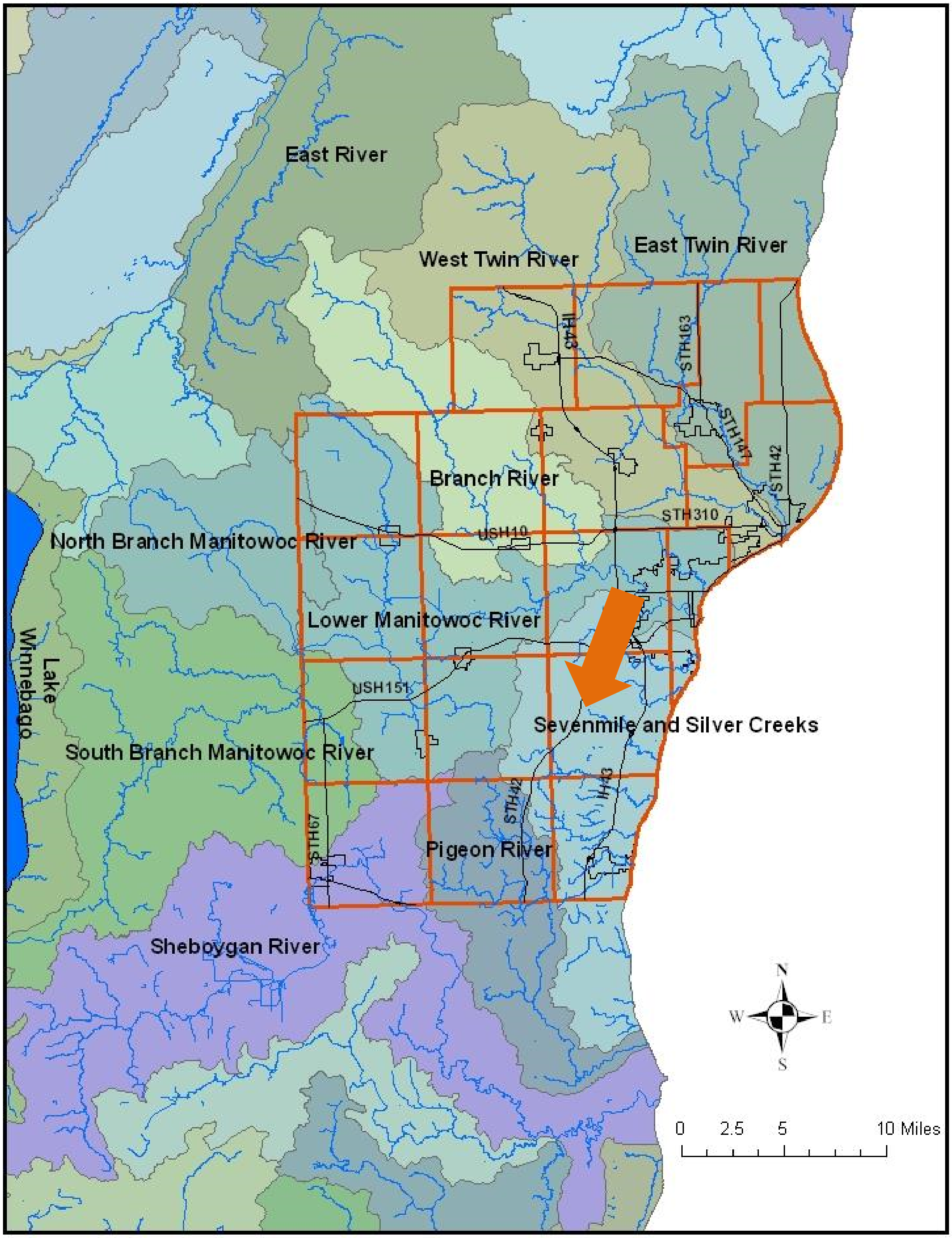
Strategy for Lake Water Quality

1) Use existing data to refine the phosphorus loading to the lake and refine the lake response models. This information will enable the specific load reductions needed for Carstens Lake to reach its water quality goals.
2) Identify priority sites (worst sources of sediment and nutrients) using the unit area loading / GIS model performed for this phase and future refinements to this modeling. Watershed BMPs will continue to be addressed utilizing existing model data pending more detailed assessments.
3) Maintain or restore riparian wetlands.
4) Conduct feasibility study to reduce legacy phosphorus in the lake, which may include wetland settling zones, muck dredging, aluminum sulfate treatments (pending completion of watershed actions), and continuing site specific aeration.
5) Conduct a preliminary feasibility analysis on artificial water level fluctuation (WLF). This could involve analysis of pumping systems, flow volumes, water control structures and permitting constraints.
6) Promote watershed management actions improving resilience of the lake ecosystem as it relates to the frequency and magnitude of flood or drought events. Resilience of the ecosystem will come from wetland preservation, restoration and possible construction of new wetlands, as well as enhancement of BMPs. These enhancements could include BMP (retention basins, artificial wetlands, storm water systems, rain gardens, buffers) construction, reconstruction, or modifications to accommodate more flooding events.
7) An annual meeting will be held (with all partners in attendance) to assess the status of the lake and in the implementation of all strategic initiatives. As appropriate changes to the plans will be discussed and a one- page summation will be written describing the year's relevant events and decisions.
8) Continue to monitor the lakes water quality using WisCALM protocols and expand the network of volunteer participation.
9) Require riparian buffers of 35 feet to reduce phosphorus loading and sediment loading via runoff and bank erosion.
10) Collect and evaluate septic tank functions of residents adjacent to the lake and within the watershed.

3.2 Watershed

A watershed is an area of land in which water drains to a common point such as a stream, lake or wetland. Carstens Lake is located entirely within the 113-square mile Sevenmile-Silver Creek (SMSC) Watershed (Figure 4). In 1984, the Sevenmile-Silver Creek Watershed was selected as a priority watershed project as part of the WDNR-administered Non-Point Source Pollution Abatement Program. The goal of the project was to reduce phosphorous loads to the near-shore area of Lake Michigan and several small inland lakes and streams. The project was officially implemented in 1986 and ended in 1996, with land inventories conducted in 1984 and 1985, and the implementation phase conducted from 1986 through the end of the project.

Figure 4. Manitowoc County Watersheds



To reach the goal of protecting and improving the water quality of the near-shore area of Lake Michigan and several inland lakes and streams in the watershed, the SMSC project was directed at reducing manure and sediment runoff from the land. To accomplish this, landowners were encouraged to participate in BMPs such as reducing winter manure spreading, installing barnyard control systems, reducing crop land erosion, restoring wetlands, and establishing stream-side buffers. Significant pollution reduction was achieved because of the SMSC project. Landowner participation in the program was considered excellent, and pollution reductions were met or exceeded in most cases. However, the draft report on the SMSC watershed project identified that many locations remain within the Sevenmile-Silver Creek watershed that could use more protection. In particular, establishing stream-side vegetative buffers was identified as a protection need, as there are still miles of streams where agricultural fields are cropped to the bank with no buffer. In addition, more surface water quality testing is recommended to further assess pollution levels and to monitor long term trends in the watershed.

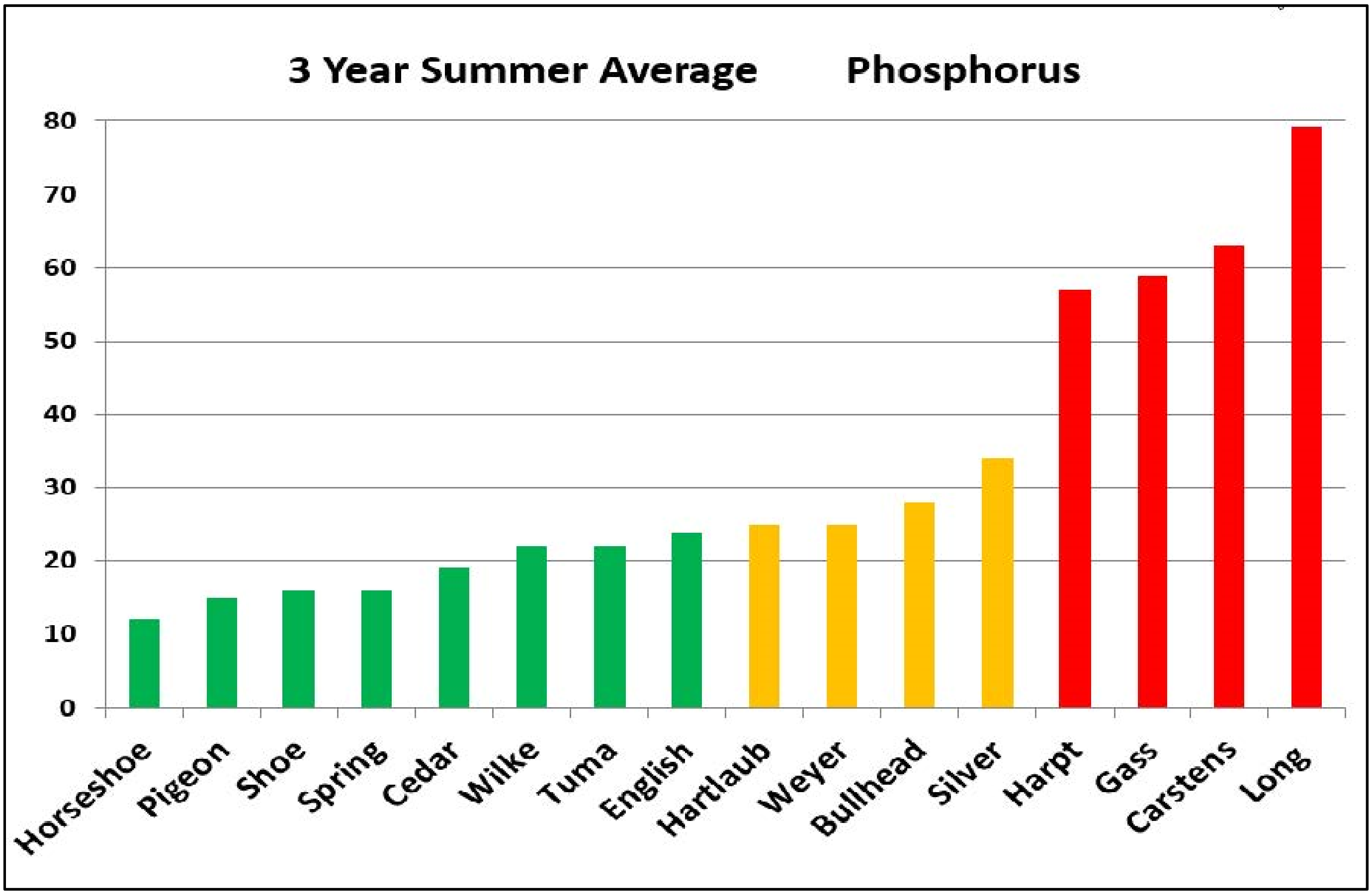
Carstens Lake is subject to impairments from a variety of sources. Major nonpoint problems impacting the lake and its watershed include sediment, animal waste and nutrient enrichment. Sediment is a primary carrier of phosphorus. Phosphorus readily attaches to soil particles and is transported to the water body through the erosion process. When soil erodes, some or most of it, eventually reaches a water body. Once in the water, the sediment increases the turbidity of the water (the water looks muddy) and this turbidity can have adverse effects on fish and other aquatic organisms.

Nutrient enrichment, primarily from animal waste and commercial fertilizer, is detrimental to surface and groundwater quality. Surface water and groundwater contaminated by animal waste can cause serious illnesses if consumed by humans. Animal waste can also be hazardous to aquatic life. Phosphorus from manure enters waterbodies and acts as a fertilizer, stimulating massive algal and aquatic plant growth. When these organisms die, they are broken down by aquatic organisms, and this decomposition process leads to High Biologic Oxygen Demand (BOD), which consumes nearly all the oxygen in lakes and streams, causing fish kills. Ammonia in manure is toxic and can kill aquatic life. Phosphorus in manure causes long-term eutrophication in lakes and streams.

Perhaps the greatest single pathway for phosphorus into the lake is via dissolved phosphorus picked up in rainwater and snowmelt. Phosphorus from manure or chemical fertilizers, if not incorporated into the soil, quickly dissolves and can be removed by excess precipitation or runoff. A critical factor in phosphorus runoff is the level of phosphorus in the soil. When phosphorus levels in the soil are high, the element is easily dissolved by rainwater and removed from the land by runoff. Once in the runoff, it easily enters streams and lakes causing algae blooms and eutrophication. Thus, high levels of legacy soil phosphorus built up in the watershed from decades of agricultural use can be a persistent source of phosphorus inputs (Motew, et al. 2017)

According to WDNR, Carstens Lake is listed as an impaired water under Clean Water Act Section 303 (d), due to Phosphorus contamination in the lake and associated Pine Creek. A three-year study, conducted by Manitowoc County Lakes Association, indicated various levels of phosphorus in 16 lakes located in Manitowoc County. The lakes listed below in Figure 5 were tested by volunteers using Wisconsin Department of Natural Resources WisCALM protocol and consist of four samples each year. Manitowoc County Lakes with phosphorus levels above 40ppb include: Harpt, Gass, Carstens, and Long Lake. Lakes between 25-39.9 ppb include: Hartlaub, Weyer, Bullhead, and Silver.

Figure 5. Phosphorus levels in Lakes 2012 - 2014



Modeling Methods

To estimate nonpoint source phosphorus loading for this revised Plan, a model based upon watershed land uses and phosphorus export coefficients was utilized. This method is consistent with the approach used to model nonpoint watershed phosphorus loading in the DNR's Wisconsin Lake Modeling Suite (WiLMS). It is also one of the procedures in the DNR's PRESTO (Pollutant Load Ratio Estimation Tool) model.

To use the Unit Area Loading model, the following categories of data were required:

- Total watershed area, from Geographic Information System (GIS) mapping and analysis
- Subwatershed (subbasin) areas and locations, also from GIS mapping and analysis. If subwatersheds are included in the model, more detailed estimated of pollutant loads from portions of the watershed can be developed.

- Land use, from GIS data
- Phosphorus export coefficients (database)

Watershed and Subwatershed Mapping

Watershed and subbasin delineation was performing using a combination of GIS and manual methods (Figure 6). A detailed Digital Elevation Model (DEM) was obtained from the National Oceanic and Atmospheric Administration (NOAA) mapping system. This DEM is based on airborne LIDAR data taken in late fall 2015. It has a horizontal grid spacing of 3 feet (finer detail than older topographic mapping and earlier DEMs) and an estimated vertical accuracy of 0.6 feet.

In GIS, the watershed boundary was delineated, using the digital topographic data, aerial photography, and stream mapping. The outlet of Carstens Lake was selected as the watershed outlet, so the watershed includes the surface of Carstens Lake. The watershed has an area of 767 acres, or 1.20 square miles and was divided into 12 subwatersheds or subbasins, so that more detailed pollutant loading estimates for individual points within the watershed can be calculated during the modeling (Figure 6). The mean subwatershed area was 64 acres. Subwatersheds range in size from 12 to 142 acres. Some subwatershed outlet points were selected to correspond to watershed monitoring locations. The major tributary that flows into Carstens Lake in its northeast corner was divided into 8 subwatersheds. Subwatersheds were also mapped for three smaller drainageways that flow into the lake on its western shore. The final subwatershed consists of Carstens Lake itself, as well as riparian and nearshore areas that drain directly into the lake without flowing into one of the delineated tributaries.

Land Use and Phosphorus Export Coefficients

Another major input in the nonpoint source pollution model was land use data. The WiLMS phosphorus export coefficients are assigned to land use categories. To support the modeling efforts, National Land Cover Database (NLCD) system from 2011 was obtained. NLCD mapping is conducted and published by a consortium of federal government agencies, and covers the entire United States in one consistent system.

According to the 2011 NLCD mapping, general land use is the Carstens Lake watershed is distributed as shown in the following Table 2. Some additional land use subcategories were used for the detailed phosphorus modeling.

Table 2. NLCD Land Use Distribution in Watershed

Land use major category	Area (acres)	Percent of total
Cropland	389	51%
Forest / wetland	128	17%
Pasture / grassland	197	26%
Urban / road right of way	32	4%
Open water	21	3%

The final input required for the watershed nonpoint phosphorus modeling is phosphorus export coefficients. To be consistent with the DNR's WiLMS and PRESTO models, the database of phosphorus export coefficients from those models were used in this study. This database was obtained from the PRESTO Documentation Manual (Version 1.1, published by Wisconsin DNR, March 2013) and is shown below.

One benefit of the DNR's database is that three estimates of phosphorus exports coefficients are given: a low value, a most likely value, and a high value. This recognizes the wide variability and uncertainty in phosphorus loads and concentrations for any given watershed. Rather than a single number, phosphorus model results should be viewed as a range of likely loads. Using the variability in phosphorus export coefficients, possible variation in total watershed phosphorus loads can be reported.

Table 3. Phosphorus Export Coefficients for Modeling

Land Use Description	Export Coefficient (lbs of phosphorus / square mile / year)		
	Low	Most Likely	High
Open Space in Developed Areas	57	171	286
Low Intensity Development	29	57	143
Medium Intensity Development	171	286	457
High Intensity Development	571	856	1,142
Cultivated Crops	286	571	1,713
Pasture/Hay	57	171	286
Grassland/Herbaceous	57	97	143
Open Water	0	0	0
Barren Land	0	0	0
Forest	29	54	103
Shrub/Scrubland	43	74	123
Wetlands	0	0	0

Sediment Modeling

The DNR's WiLMS / PRESTO unit area modeling approach focused on phosphorus, and does not include the calculation of sediment loads such as total suspended solids (TSS). One common method for calculating nonpoint sediment loads in rural areas is the EPA (Environmental Protection Agency) Spreadsheet Tool for Estimating Pollutant Loads (STEPL) model. STEPL is a Microsoft Excel based model that predicts annual sediment loads for rural watersheds and drainage areas based upon land use, climatic and other data. STEPL was used for this project to estimate sediment loads. Similar input data – primarily land use data – as used for the phosphorus modeling was used for the STEPL analysis.

Modeling Results

Phosphorus Loads

Using the methods described in the Modeling Procedures section, estimated total phosphorus loads to Carstens Lake from nonpoint sources in the upstream watershed were calculated. As stated earlier, the WiLMS loading coefficient allows for the estimate of a range of expected phosphorus loads: low, most likely and high expected values. Table 4 gives the range of estimated annual phosphorus loads for the watershed.

Table 4. Total Nonpoint Phosphorus Loads from Watershed

Estimate Range	Total P (lbs/average year)
Low end	192
Most Likely	400
High end	1,125

Tables 5 and 6 show the estimated total phosphorus loads ("most likely" loads) summed by subbasin/subwatershed, and by land use.

Table 5. Total Phosphorus Loads by Subbasin

Subbasin	Average nonpoint phosphorus load, lbs per year
Main tributary - LAKE	10.4
Main tributary – SP1	25.0
Main tributary – SP2	31.6
Main tributary – SP3	77.7
Main tributary – SP4	63.9
Main tributary – SP5A	41.5
Main tributary – SP5B	84.8
Main tributary – SP5C	4.8
Boat Ramp Tributary	34.5
West Tributary	3.2
Northwest Tributary	6.5
Local direct runoff to lake ("Lake Outlet")	16.0
Total	400

Table 6. Total Phosphorus Loads by Land Use

Land use major category	Average nonpoint phosphorus load, lbs per year
Cropland	341.9
Forest / wetland	1.8
Pasture / grassland	52.0
Urban / road right of way	4.3
Total	400

Note that the loads shown in the tables are not cumulative loads, but represent the incremental load to each subbasin outlet from direct runoff from that subbasin. Atmospheric deposition is not included in the totals above, but is estimated to contribute approximately 6 pounds of phosphorus per year.

Sediment Loads

Using the STEP-L spreadsheet model, total sediment loads for the watershed were estimated. The estimated average annual sediment load is 355 tons per year, or 710,000 pounds per year. Table 7 shows calculated sediment loads by subbasin.

Table 7. Estimated Sediment Loads by Subbasin

Subbasin	**Average nonpoint sediment load, tons per year**
Main tributary - LAKE	10
Main tributary – SP1	22
Main tributary – SP2	27
Main tributary – SP3	74
Main tributary – SP4	57
Main tributary – SP5A	38
Main tributary – SP5B	75
Main tributary – SP5C	4
Boat Ramp Tributary	29
West Tributary	2
Northwest Tributary	5
Local direct runoff to lake ("Lake Outlet")	13
Total	355

Preliminary Consideration of Management Options

Structural measures

One strategy to reduce phosphorus and sediment loads in a watershed is to construct engineered infrastructure to trap, settle or filter pollutants in concentrated runoff. A sediment basin is one type of engineered, structural BMP. To evaluate the possibility of using sediment basins to manage nonpoint source pollution in the Carstens Lake watershed, a preliminary sizing of sediment basins was performed using Natural Resources Conservation Service (NRCS) methodology. NRCS Conservation Practice Standard 350 provides guidance on sizing criteria and other design recommendations.

The lower in a watershed a sediment basin is located, the more sediment and phosphorus it can potentially manage – but the larger it must be to provide that management. Sizing calculations were performed for several possible sediment basin locations in the lower reaches of the main Carstens Lake subwatershed (the Pine Creek tributary). The locations are described in the Table 8 and shown on Figure 6.

Table 8. Sediment Basin Preliminary Sizing

Location	Drainage area (acres)	Required basin surface area* (acres)	Estimated annual phosphorus removal (lbs)
1. Either side of Carstens Road, approx 0.1 miles east of Hwy 42	405	8	110 (28% of watershed load)
2. North side of Carstens Road, approx 0.3 miles east of Hwy 42	530	11	155 (39% of watershed load)
3. South side of Carstens Road, approx 0.5 miles east of Hwy 42	580	12	178 (45% of watershed load)

*Each basin is sized assuming no upstream basins. If multiple sediment basins are constructed in series, the size of individual basins could be reduced.

Sediment basins designed using NRCS methodology typically remove about 80% of the average annual incoming suspended solids load and 60% of the incoming phosphorus load. Using the sizing methodology of NRCS 350 and some initial assumptions about sediment basin geometry, the estimated sediment basin sizes and phosphorus load removals are shown in the Table 8.

Further evaluation of potential sediment basin locations will be required to assess their feasibility in detail. This evaluation would include an assessment of land availability, estimated cost, topography and grading, soils and subsurface conditions, and permitting and regulatory considerations. More detailed hydraulic and water quality modeling would also be performed to refine the required basin sizes.

For any structural measures proposed, an Operations and Maintenance plan would be prepared with the design plans. The minimum requirements to be addressed in an Operations and Maintenance plan should include:

- Periodic inspections and maintenance of the embankments, principal and auxiliary spillways and dewatering device especially following significant runoff events.
- Prompt repair or replacement of damaged components.
- Prompt removal of sediment when it reached pre-determined storage elevations.
- Periodic mowing or vegetation to control trees, brush and invasive species.
- Periodic inspection of safety components and immediate repair if necessary.

Nonstructural measures

As an alternative to infrastructure such as sediment basins, nonstructural management measures can be implemented in the watershed. The STEPL model can be used to perform a preliminary analysis of various nonstructural phosphorus and sediment reduction techniques on agricultural land, including:

- Conservation tillage

- Contour farming
- Filter / buffer strips
- Terracing

The model was used to estimate the watershed nonpoint phosphorus reduction that would be expected from several of these nonstructural management techniques. These measures were analyzed when applied to cropland, which generates a large majority of the nonpoint source pollution in the watershed. Calculations were performed for both 100% coverage and 50% coverage of that management measure (Table 9).

Table 9. Nonstructural management techniques for nonpoint reduction

Cropland management scenario	Watershed phosphorus reduction
Conservation tillage, 100% coverage	54%
Conservation tillage, 50% coverage	27%
Contour farming, 100% coverage	36%
Contour farming, 50% coverage	18%
Filter strips, 100% coverage	55%
Filter strips, 50% coverage	28%

Comparison of the phosphorus reductions from the construction of large sediment basins and widespread implementation of nonstructural cropland measures shows that the two strategies produce phosphorus reductions of a similar order of magnitude.

Potential Future Analysis

The modeling conducted for this Plan is envisioned as the first step in a process of adaptive analysis, planning and implementation. As scoped in the WDNR grant, watershed sediment and phosphorus loads were estimated using unit area loading techniques. As resources, time, and funding permit, there are numerous analysis and planning tasks that can be undertaken to refine the analysis of existing conditions and enhance management planning.

Analysis of Monitoring Data

If nonpoint pollutant loading monitoring data is available for the watershed, the modeling can be calibrated to match observed conditions to the extent possible. For the past several years, stakeholders and volunteers have been collecting grab samples of streamflow at several locations in the Carstens Lake watershed. The monitoring locations include five locations upstream of Carstens Lake on the main tributary, in addition to the outflow from Carstens Lake. The grab samples were analyzed for total phosphorus concentrations. In some cases, the samples were also analyzed for total suspended solids (TSS) concentrations. Separately, measurements of water depths and velocities were also made at two culverts on the main tributary. This data can be used to estimate water flow. These measurements were generally made on different days than the water quality sampling, and in the future, it is recommended that the timing of water quality sampling and flow measurements be synchronized if possible.

It can be challenging to use point samples to estimate overall annual pollutant loading, but some general observations can be made from the data collected to date. Sampling Station 5 (Figure

6) is a short distance upstream of Carstens Lake on the main tributary, and is the best available representation of overall runoff flow into Carstens Lake. For the 2016 sampling season, phosphorus samples were collected on 19 days throughout the year. The arithmetic mean of total phosphorus concentrations (as tested by total phosphate, a close proxy for total phosphorus) was 0.47 mg/L. The geometric mean (another statistic that represents central tendency, while reducing the effect of individual extreme values) was 0.31 mg/L. The modeled phosphorus loads can be combined with runoff volume estimates from WiLMS to estimate average annual modeled phosphorus concentrations in runoff. The modeling predicts that average annual phosphorus concentrations in watershed runoff range from a low estimate of 0.15 mg/L to a high estimate of 0.88 mg/L, with a "most likely" value of 0.31 mg/L.

If it is assumed that the means of grab sampling data are a reasonable approximation of average phosphorus concentrations in runoff, then the monitoring data and the modeling results are in the same range, indicating that the modeling is likely a good prediction of actual phosphorus loads. To fully use the monitoring data to calculate actual annual pollutant loads, a flow-weighted analysis would be needed. A hybrid of actual water quality measurements, rainfall and other climatic data, and a streamflow simulation model or a continuous monitoring record of streamflow would be combined to estimate daily phosphorus loads. Such an analysis is outside of the scope of the current project but could be performed in the future.

Septic Tank Loading

A preliminary estimate of phosphorus loads from septic tanks near Carstens Lake was made using WiLMS. It is estimated that the loading from this source is contributing 4 pounds of phosphorus annually. This is only 1% of the estimated annual contribution from nonpoint sources in the watershed. This estimate could be refined with additional data on population, residence usage, site soil conditions, and age/condition of septic systems.

Detailed assessment of current watershed management measures

This initial nonpoint pollutant loading analysis is based primarily on land uses, drainage areas, and typical phosphorus contributions from average Wisconsin agricultural areas. Predicted phosphorus loads do not account for existing management measures that may already be implemented in the watershed. In the future, management measures already being implemented on individual farms could be reviewed with stakeholders, to credit these existing practices in the analysis.

Comparison of modeled and monitored in-lake phosphorus loads

WiLMS contains procedures for predicting in-lake phosphorus concentrations, based upon predicted watershed loads, predicted runoff and lake hydrographic and bathymetric characteristics. WiLMS predicted average in-lake phosphorus concentrations for Carstens Lake using 12 different prediction equations from lake chemistry research. The means of all 12 predictions were then calculated. Like pollutant loading, WiLMS reports a range of predicted values, including low, "most likely" and high.

The "most likely" average in-lake phosphorus concentration for Carstens Lake predicted by WiLMS was 139 micrograms/L. The low range prediction was 71 micrograms/L, and the high range prediction was 365 micrograms/L. In comparison, the monitored spring turnover phosphorus concentration for Carstens Lake averaged 148 micrograms per liter from 2014 to 2017. The monitored growing season phosphorus concentration averaged 77 micrograms per liter from 2014 to 2017.

Therefore, model-predicted and monitored in-lake phosphorus concentrations are in the same range, though the average modeled results appear to be somewhat higher than average monitored results. This analysis could be conducted in more detail in the future, though based upon this initial analysis, the modeling appears to provide reasonable results. If modeled in-lake phosphorus results are very different from measured in-lake phosphorus results, it may indicate that the contributing phosphorus inflows to the lake are incorrectly accounted for, or there is a significant source or sink of phosphorus (such as existing lake sediment) that is not yet recognized.

Phosphorus Reduction Goals

Phosphorus reduction will be achieved through the following actions:

1. **Strategically placed BMPs** – Further evaluate the feasibility and cost of strategically placed sediment basins as described in the previous section. Projected funding would be through a Lake Protection Grant (75% State, 25% Local Partners).
2. **Evaluate Nonstructural and Distributed BMPs in target subbasins -** Utilize the results of this study to identify subbasins contributing disproportionately high amounts of P. For these "problem subbasins", write grants to address these areas by installing corrective nonstructural or distributed structural BMPs. Projected funding would be through a Lake Protection Grant (75% State, 25% Local Partners) or other funding sources.
3. **AIS Treatment Plan** – Prevention of anaerobic conditions favoring phosphorus release from sediments will also be considered. This source of phosphorus release can potentially be managed with strategically designed mechanical harvest in conjunction with selective chemical control of Eurasian Water Milfoil (*Myriophyllum spicatum*). Funded by AIS Control Grant.
4. **Buffer Work** – Work with County to enhance vegetated buffer strips along drainageways, pursue agricultural shore land management ordinance (County-wide). Funded through a Lake Planning Grant along with additional assistance by local partners.
5. **Evaluate BMP feasibility –** Work with partners to identify, prioritize and implement BMP's in the watershed (example: sediment basins). Maintain existing BMPs where needed.

Watershed Objectives

- Reduce nonpoint pollution sources by 10% over the next 10 years
- Integrate and support objectives with the Manitowoc County Soils and Water Conservation Department
- Protect surface waters from flooding and riparian zones from heavy erosion
- Improve agricultural operations compliance with NR151 standards
- Determine % of sediment and phosphorus loads from agricultural sources
- Inventory shoreline conditions (integrates with Objectives in shoreland strategy section)

- Improve awareness in the community regarding watershed influence on water quality (integrates with objectives in Education and Outreach strategy section)

Watershed Strategy (Carstens Lake and County-wide)

1) Integrate watershed objectives with all current and proposed water quality strategies, administered or under the guidance of The Soil and Water Conservation Department. These strategies include the following practices:

Priority Practice	Purpose
Manure Storage Facilities	Allows farmers to store manure until optimum spreading times. This facilitates application of animal waste during seasons when there is decreased runoff vulnerability.
Barnyard Runoff Control Systems	Diverts clean water away from barnyards. Runoff is either collected or filtered to reduce or eliminate discharge. Types include: containments, collection devices, clean water diversions, roofs, grass filters, settling basins, and fencing.
Grassed Waterways	Prevents gully erosion, reduces nutrient and sediment runoff and protects water quality.
Wetland Restorations & Sediment Retention Basins	Traps and treats sediment and nutrients, reduces flooding and provides wildlife habitat.
Conservation Buffers	Traps sediment and nutrients from cropland runoff, provides setback area between cropland application of fertilizer and pesticide and waterways, and provides wildlife habitat.
Conservation Easements	Permanent protection of restored wetlands or stream corridor areas.
Nutrient Management Plans	Intended to minimize nutrient entry into surface water, groundwater, and atmospheric resources while maintaining and improving the physical, chemical, and biological condition of the soil. (30% of cropland is NOT certified in NMP)
Conservation Crop Rotations	Reduces sheet, rill and wind erosion, manages balance of plant nutrients, manages plant pests, and improves soil organic matter content.

Vegetated Treatment Areas	Absorb nutrients, organics, pathogens, and other contaminants associated with livestock, poultry and other agricultural operations.
Feed leachate and milkhouse waste control systems	Reduce or eliminates milking center waste water discharge and discharge from field storage structures.
Cover Crops	Improve soil health, improve soil structure, increase organic matter, manage excess nutrients in the soil, minimize soil compaction, promote nitrogen fixation, and reduce erosion.
Reduced Tillage	Reduce erosion, improve soil condition, reduce energy use, provide food and escape cover for wildlife.
Subsurface Drainage	Repair tile blowouts to eliminate transfer of manure and nutrients to surface water.

2) Continue to support or expand BMPs funded by United States Department of Agriculture: NRCS: *Environmental Quality Incentive Program (EQIP); Conservation Reserve Program (CRP); Conservation Stewardship Program (CSP); Conservation Reserve Enhancement Program (CREP); and Agricultural Conservation Easement Program (ACEP).*

3) Enhance watershed Education and Outreach (joint effort across Manitowoc County)

- Conduct storm drain awareness campaign,
- Include shoreline property owners, home owners, agriculture community, urban residents,
- Erect "Carstens Lake Watershed" road signs at all watershed boundary points, especially along main roadways such as State Highway 42.

4) Identify primary sources of nonpoint inputs
5) Ensure wetlands function for optimum water quality filtration (i.e. ensure plant abundance).
6) Review Nutrient Management Planning efficacy and compliance.
7) Identify working committee to carry out the following:

- Define and identify critical areas.
- Prepare a site specific financial incentive package utilizing existing Federal and State programs as well as partner funds. Leverage key progressive farmers in the watershed that are well-respected in the watershed.
- Present the financial incentive package to the landowner during "one on one" meetings.
- Assist the landowner with any and all program signup paperwork, and permit requirements.
- Assist the landowner with securing resources for the installation of the appropriate BMPs. Harvested buffers are recommended (they function

well, do not grow up in brushy vegetation, and the harvesting actually removes some phosphorus).

- Track accomplishments through GIS.
- Utilize enforcement tools as necessary for non-cooperating landowners with critical sites

8) Grants (see Section 4.0 for additional discussion)
    - Planning grants – Modeling along with load appraisal studies, will be employed to inform watershed improvement decisions. Consecutive, staged grant projects would likely be required.
    - Protection Grants – Pursue grants for BMP's to address the high priority sites. Prioritize the worst areas and work down the list while consulting with a committee to prioritize watershed work.
    - Targeted Runoff Management (TRM) Grants – Grants will be pursued based on availability, applicability, need, and workload capacity
    - Knowles-Nelson (K-N) Stewardship Grants
9) Review agricultural operations within the watershed for compliance with NR151 agricultural standards.
    - Identify operations that are not meeting current standards
    - Prioritize operations based on sediment loading and distance
    - Utilize programs to bring operations into compliance (EQIP, TRM, SWRM, etc.)
    - Review efficacy of BMPs utilizing pre/post sampling for TSS and TP

3.3 Water Quality of Tributary Streams

Two tributary waterways have been identified that discharge directly into Carstens Lake: the waterway identified as the upper portion of Pine Creek, which enters at the northeast end of the lake; and a tile outflow that enters at the southwest shore of the lake near the boat landing. Portions of upper Pine Creek and tributaries within the watershed have been ditched and straightened for agricultural drainage, which has resulted in faster, flashier flows and a degradation in aquatic habitat.

Both of these tributaries were found to be major contributors of phosphorus to the lake, with Pine Creek contributing roughly four times more phosphorus than the tile outlet (NES, 2003). The two tributaries are highly impaired due to agricultural nutrient loading, channelization, a dominance of invasive plant species, a lack of a defined channel and flashy flow regimes.

Objectives for Stream Water Quality

1) Improve understanding of stream and riparian condition and trends in tributary pollutant levels, sedimentation, riparian land practices (farming, grazing, etc.) and habitat utilization

2) Restore stream habitat, riparian wetlands and uplands, and water quality within degraded tributary
3) Advocate for water quality improvements by discussing modified agricultural practices within the immediate watershed. This could include land spreading activities, fertilizer and pesticide applications, buffer strips, or no-till farming

Strategy for Stream Water Quality

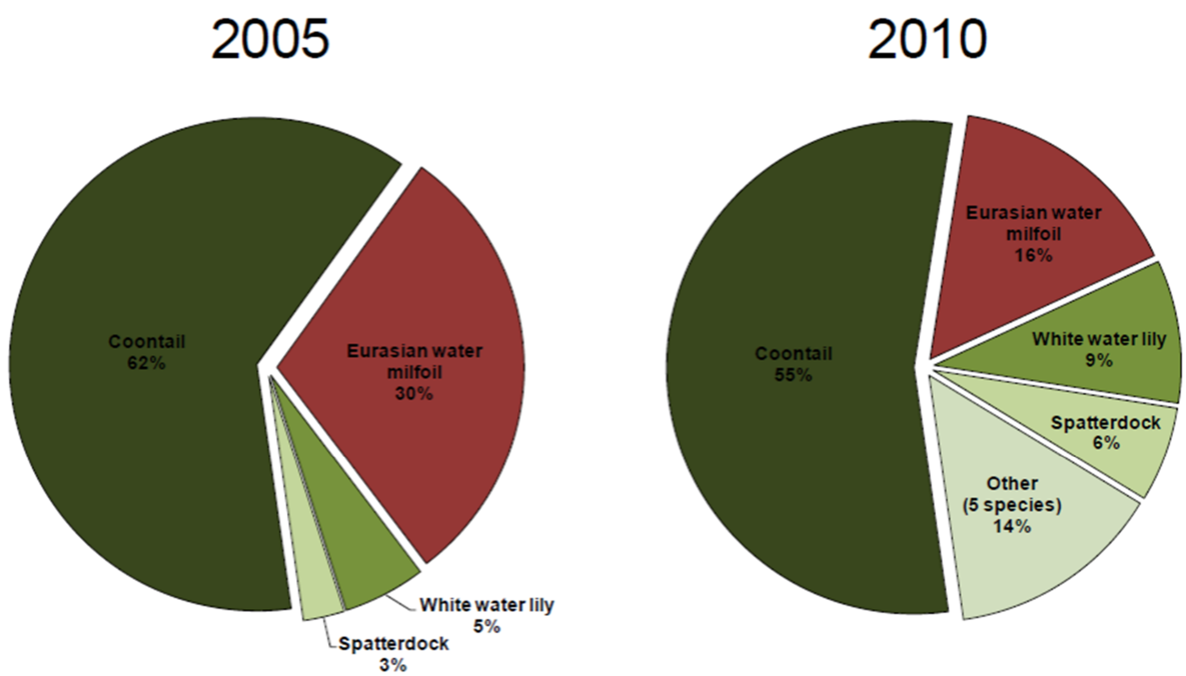
1) Evaluation of BMPs- Employ USGS or similar methodology to evaluate efficacy of implementation. To meet current criteria for receiving grants from federal or State programs, evaluation of objectives achieved and successes and failures, are required. This will be completed on 2 levels;
    - Level 1 – Longer range general lake or stream condition appraisals that will show macro trends. On-going lake and tributary monitoring by WDNR and volunteers are examples. Detailed watershed modeling would also fall into this category
    - Level 2 – Focused evaluations specific to the site where BMP employed. Can involve upstream vs. downstream studies, biotic indexing, physical surveys (Bank Erosion Hazard Index (BEHI), sediment transport modeling, geomorphic modeling, etc.), or other appropriate methods characterizing the before and after conditions, and how it might affect the lake. Other evaluations could involve riparian buffers, stream bank repairs and channel realignment, modeled nutrient and sediment loadings, wetland restoration, anecdotal evidence, images, and other acceptable modifications.
2) Maintain existing tributary BMPs where needed (e.g., sediment basins, buffer areas, etc.).
3) Annual meeting to assess progress, make changes, improvements, or further actions. A one-page summation should describe the year's relevant events and decisions, with all partners in attendance.
4) Evaluate the efficacy of existing or installed BMPs to determine if the BMPs are working as proposed. Monitor relevant parameters of water quality including Secchi disk clarity, Chlorophyll A concentrations, Total P, T.S.S., T.V.S.S., temperature, oxygen, pH, fishery evaluation and PI. The frequency of monitoring these parameters will be variable, but within standard norms for the limnological assessment of lake health. This will allow for improved data review respective of cause-and-effect conclusions.
5) Collect and evaluate septic tank functions of residents in the watershed.

3.4 Lake Habitat and Plants

Aquatic plants form the foundation of healthy and flourishing freshwater ecosystems. They not only protect water quality, but they also produce oxygen which is crucial to fish and other aquatic life. Aquatic plants are a lake's own filtering system, helping to clarify the water by absorbing nutrients like phosphorus and nitrogen that could stimulate algal blooms. Plant beds stabilize soft lake and river bottoms and reduce shoreline erosion by reducing the effect of waves and current. Healthy native aquatic plant communities help prevent the establishment of invasive non-native plants, e.g. Eurasian water-milfoil and purple loosestrife.

The most recent aquatic vegetation survey of Carstens Lake was completed by in July 2010 by Onterra LLC (Butterfield, et al. 2010) in response to concerns brought by the Manitowoc County Lakes Association and lakeshore property owners regarding increased growth of aquatic plants, primarily Eurasian water milfoil, throughout littoral areas of the lake. An aquatic plant point-intercept survey using WDNR methodology was used to characterize spatial distribution and abundance of submersed native and non-native aquatic plants. The data collected during this survey indicated that the native species coontail (*Ceratophyllum demersum*) was the dominant plant within the plant community and has increased in occurrence by over 50% since a survey conducted in 2005. Eurasian water milfoil was the second-most frequently encountered species and decreased slightly in occurrence since 2005 (Butterfield, et al. 2010). Although the dominant aquatic plant species present are native, invasive Eurasian water milfoil has become established and according to WDNR data, this species invaded Manitowoc County lakes beginning in the 1980s.

Figure 7. Carstens Lake 2005 and 2010 aquatic plant relative frequency of occurrence anaylsis (from Butterfield et al., 2010)



During the 2010 survey, native coontail was observed matting on the surface throughout the entire littoral area of the lake, creating a nuisance condition. In 2010, all species observed except for Eurasian water milfoil increased in their littoral frequency of occurrence, and overall, 90% of the point-intercept locations within the littoral zone contained aquatic plants in 2010 compared to 61% in 2005. Data collected from the aquatic plant surveys indicate that the average conservatism values from the 2005 and 2010 surveys also fall below both the ecoregion and state medians. This indicates that when compared to other lakes within the region and state, the plant community of Carstens Lake is of lower quality and indicative of a disturbed system. In lakes with high nutrient inputs, like Carstens Lake, the species that are best adapted to access these nutrients directly from the water, like coontail, out-compete other species for space and light. Thus, the plant community within Carstens Lake is comprised of species that are more tolerant to environmental disturbance. The complete 2010 report, *An Aquatic Vegetation Survey of Carstens Lake*, can be found on the MCLA website:

http://www.manitowoccountylakesassociation.org/Carstens -lake/

Abundance of aquatic plants at this level can negatively impact the ecosystem by causing anoxic (without oxygen) conditions that result from the decomposition of plant and algal material during the winter months. Occasional winter fish kills have been observed on Carstens Lake, which has required the use of an aeration system to supply oxygen to the lake during the winter months.

Objectives for Aquatic Plants and Habitat

1) Reduce the user conflicts via integrated strategy including mechanical harvest, herbicide applications, education and outreach, and defining/employing riparian development guidance
2) Protect integrity of the native aquatic plants and woody shoreline habitat
3) Restore shallow water habitat of the lake and tributary areas
4) Control expansion of non-native invasive plants
5) Evaluate the aquatic plant population trends
6) Restore woody habitat on lakeshores
7) Promote natural shoreline habitat strips, discourage mowing to lakeshore

Strategy for Aquatic Plants and Habitat

1) Review education and outreach needs and subsequently enhance for the lake environments, including the watershed.

2) Evaluate feasibility of control efforts for nuisance aquatic plants, such as mechanical removal (hand-pulling, raking and hand-cutting), bottom screens, water level manipulations, mechanical harvesting, herbicide treatment or biological controls.

3) Complete Point Intercept plant surveys at a minimum frequency of once every 5 years for the entire lake. This appraisal will identify trends in the plant community.

4) Appraise feasibility for Eurasian water milfoil and curly-leaf pondweed (*Potamogeton crispus)* control on lake

3.5 Aquatic Invasive Species (AIS)

Carstens Lake has been impacted by stressors including invasive species. Introduction of aquatic invasive species to the lake include species that are currently spreading in Wisconsin lakes and having an impact on fisheries and aquatic habitats. These have and may include aquatic plants, animals, and pathogens. A fish barrier in Pine Creek has been used to prevent common carp from

Lake Michigan entering Carstens Lake (MCLA, 2000), which could protect Carstens Lake from invasive Asian carp species in the event they become established in Lake Michigan. Some invasive species may have a profound effect on water quality. The spiny water flea (*Bythotrephes longimanus*) first invaded the Great Lakes in the 1980s, and since 2000 has spread to inland lakes in several parts of Wisconsin (WDNR, 2017). This species is a predator of native waterfleas (*Daphnia),* which consume algae, reducing phosphorus levels. Invasion of spiny waterflea in other Wisconsin lakes has resulted in a collapse in *Daphnia* populations (Motew et al, 2017). Eurasian water milfoil is currently the dominant AIS concern in the lake. Nuisance aquatic vegetation exists, in part, because of this species abundance and distribution in the lake.

Purple Loosestrife (*Lythrum salicaria)*, a showy, purple-flowered invasive, appears to be suppressed in several areas in the watershed near the lake. The invasive common reed grass (*Phragmites australis* subsp. *australis,* or more commonly known as "Phragmites"), is an extremely aggressive non-native grass that has begun to colonize roadsides, wetlands, and shorelines throughout the Great Lakes region. The spread and colonization of this species has severe consequences to native ecosystems, reduces access to recreational opportunities, degrades view sheds and aesthetic appeal of beaches and shorelines, and has negative economic impacts including reduced property values, with an associated reduction in property tax revenues. One population of Phragmites is known to occur within the watershed and several more populations have been documented in close proximity to the watershed boundary. Suppression efforts should be initiated and will need to continue into the foreseeable future to ensure this species does not invade the lake.

Several lakes within Manitowoc County, including Carstens Lake and its tributaries, have AIS education and prevention as goals in their respective lake and/or aquatic plant management plans. However, funding to execute those goals is limited. Additionally, there are several lakes where no and/or limited AIS prevention activities are being implemented. As a result, Manitowoc County's AIS prevention and education activities remain a patchwork of varying AIS efforts.

In recent years AIS prevention actions have been initiated among partners;

1) The AIS coordinator is responsible for education and outreach.
2) Manitowoc County Lakes Association conducts a clean boats clean water program (CBCW) during the summer with a part-time staff including 1 coordinator and several landing inspectors. They provide AIS education around Manitowoc County.
3) WDNR has provided grants and technical assistance for AIS work including Clean Boats Clean Waters program support, monitoring of new infestations, and access point postings at the lake and regionally.
4) Partners organizations have secured grant funding to control *Phragmites* within the Carstens Lake watershed, but continued monitoring and if necessary, treatments will be required long-term.

<u>Aquatic Invasive Species (AIS) Objectives</u>

1) Prevent AIS spread (i.e., import and export)

2) Control AIS populations as reasonable in the lake and tributaries
3) Appraise conditions and trends in AIS populations
4) Educate and inform the public
5) Establish responsibility for AIS coordination

Aquatic Invasive Species (AIS) Strategy

1) Form an Aquatic Invasive Species (AIS) steering team for Carstens Lake (combined with regional effort) to manage lake inventory and monitoring, reporting, grant writing, contracting and rapid response treatments as needed.
2) Conduct feasibility analysis for lake wide Eurasian water milfoil and curly-leaf pondweed control. If needed, retain qualified professional assistance to develop a specific project design to control these species and early detection of new invaders utilizing mechanical removal (hand-pulling, raking and hand-cutting), bottom screens, water level manipulations, mechanical harvesting, herbicide treatment or biological controls; or a combination of control options.
3) Apply for WDNR Aquatic Invasive Species Grant based on developed project design.
4) Conduct quarterly review of AIS activity and update plan to reflect changed in control needs and those of the lake ecosystem.
5) Integrate all partners with Carstens Lake AIS actions
6) Integrate Carstens Lake strategy implementation with regional coordination efforts
7) Continue to staff monitors at the public boat landing trained by the Clean Boats Clean Waters program. Continue to offer boat washing station.
8) Encourage education partners to be part of AIS program execution

3.6 Fishery

Carstens Lake historically supported a bass-panfish-northern pike fishery, however fish habitat and populations declined over the past five decades (MCLA, 2000; Surendonk, 1999), as excess phosphorus, algae blooms, carp, low oxygen levels, and winter kills have taken a toll.

Today, Carstens Lake has serious challenges for fish habitat. Chief among these are low oxygen levels leading to winterkills, which have necessitated the operation of an aerator in the lake. Fishery and fish habitat within Carstens Lake have declined since the 1950s from a relatively diverse mix of panfish and sport fish to a poor fishery composed largely of common carp and black bullhead. In the mid to late 1950s the fishery data available from local anglers suggests largemouth bass, northern pike, bluegill, crappie, common sunfish, golden shiner and perch were common catches. However, by 1963 the fisheries biologist reported the lake was "a mess". At that time, species identified were largemouth bass, bluegill, black crappie, white sucker and common carp. By 1975, WDNR reported the presence of largemouth bass, northern pike, bluegill, black crappie, pumpkinseed, white sucker, common carp, black bullhead and golden shiner, with gamefish and panfish found to be stunted, and carp were large. The first recorded winterkill occurred in winter 1976-1977, after which the fishery became increasingly dominated by roughfish. Fish stocking perhaps started in 1977, and then sporadically thereafter. Despite stocking, by 1980, black bullhead, black crappie and common carp dominated the fish population. It was decided that stocking efforts had failed, and the lake was treated with rotenone to kill off the fish population in September 1982. Subsequent partial winterkills were also reported in 1997-98, and again in 1999-2000. Repeated winter kills have resulted in disappearance of desirable fish species intolerant of low oxygen levels, and the trend of the fishery toward dominance by common carp and black bullhead (Surendonk, 1999). For detailed fishery data, visit the WDNR Carstens Lake summary page at: http://dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=66800&page=more

In the 2000 Plan and again in this revised version, an area of fish spawning habitat was identified in the upper portion of Pine Creek draining into Carstens Lake, and the surrounding hardwood swamp. This area receives direct surface water drainage from the adjacent crop fields, which likely compromises the quality of habitat for fish spawning.

Aquatic vegetation provides crucial habitat structure for fish, and the lake has supported a fishery dominated by bluegill and largemouth bass in recent years. Northern pike, which historically were present, and noted to spawn in upper Pine Creek and wetlands adjacent to the north end of the lake, were rare or absent in 2010-2015 surveys. Rotenone treatment followed by stocking and installation of a fish barrier appear to have been successful in keeping roughfish out of the lake. Despite these successes, WDNR categorizes Carstens Lake's fish and aquatic life condition as "Poor" (WDNR, 2015). The issues affecting the fishery are inter-related and enmeshed with long-term conditions prevailing across the watershed.

Objectives for the Fishery

1) Improve public education and outreach opportunities to integrate with fish management activity
2) Protect/enhance spawning habitats and nursery areas within the lake and within adjacent wetlands (i.e., in shallow waters)
3) Restore degraded fish spawning and nursery areas within the lake and adjacent wetlands
4) Conduct routine sampling to assure the health of the fishery

Strategy for the Fishery

1) Ensure the protection and maintenance of sensitive areas for nursery, feeding, shelter through support of cross strategies for aquatic plants and water quality
2) Conduct an analysis of problem areas of filamentous algae growth
    a. Determine areal coverage and evaluate growth trends of filamentous algae
    b. Conduct appraisal of causal factors (nutrients in groundwater, land runoff and climate change)
3) Enhance existing wetland connections to the lake (scrub-shrub wetland on west side of lake, Pine Creek forested wetland on north end of lake and wet meadow wetland north of the forested wetland) to provide additional spawning and rearing habitat for fish

   a. Remove invasive herbaceous and shrub species within the wetland areas
   b. Re-establish native sedge, wet meadow and shallow marsh vegetation
   c. Realign existing stream channels in the two wetland areas to maintain hydraulic connection with adjacent wet meadow floodplain and forested wetland habitats. This will also increase residence time of overland flow to remove additional suspended solids and nutrients.
      1. Incorporate off-channel shallow marsh/ponds to further increase residence time for overland flow, and add additional habitat for spawning and rearing fish, amphibians and birds
      2. Ponds to include woody debris, log and brush to provide cover for fish and protection from predators
   d. Channel realignment to include appropriate stream pattern and profile, riffle-pool sequence and floodplain hydraulic connection
      1. Channel to include constructed riffles, deep pools and woody debris

4) Grants – pursue watershed restoration and enhancement grants that include stream restoration (money for design and implementation), habitat enhancement and sediment and nutrient reduction programs.

3.7 Natural Communities and Land Conservancy

Nearly half of the shore of Carstens Lake is comprised of wetlands or wetland indicator soils (Figure 8). In addition, the lake's watershed comprises numerous wetland basins, which, like Carstens Lake, are situated in glacially-formed depressions. Based on a site survey in 2017, the watershed is composed of approximately 5.4% upland forest, 14% forested wetland, 3% herbaceous wetland, 2.3% upland shrubland and 72% comprised of agriculture and developed areas (Figure 9). The wetlands in the watershed are composed primarily of high quality hardwood swamp communities, and less commonly, wet meadow and farmed wetlands. The wetlands are likely subject to siltation and runoff from surrounding upslope agricultural lands. Additional impairments to wetlands in the watershed have resulted from past ditching and agricultural drainage, which have resulted in disruptions to natural hydrology, and likely led to artificially lowered water table. Protecting or enhancing the ecological integrity of these wetlands is critical to filtering surface water flows and reducing phosphorus inputs to Carstens Lake.

Installing buffers of perennial vegetation adjacent to wetlands and waterways can have a profound effect on reducing phosphorus and sediment inputs, absorbing surface water runoff, and keeping excess nutrients from flowing into Carstens Lake. Water storage and uptake by plants from evapotranspiration within perennially vegetated areas can help reduce the flashy behavior of the tributaries flowing into Carstens Lake. Where feasible, wetland restoration should be considered on marginal/fallow agricultural lands. Hydrologic restoration should include filling of drainage ditches and destruction of drain tile.

At present, there are no properties under conservation protection within the watershed. Some natural communities warrant conservation protection due to their unique aesthetic features and values and the water quality protection afforded the lake.

Objectives for Lands Conservancy and Aesthetic Preservation

1) Develop organizational partnerships to support landowner outreach
2) Seeking opportunities for land conservation and preservation
3) Educate landowners on the need for conservation and preservation practices

Strategy for Land Conservancy and Aesthetic Preservation

1) Support and maintain conservation partners through grants, donations, financial incentives and community actions
2) Work actively with realtors and property owners regarding conservancy opportunities
3) Identify a vision for the next level of objectives in the conservancy partnership
4) Survey existing property uses
5) Promote conservation success stories
6) Protect sensitive features on properties with unique qualities, and restore, to the degree reasonable, all properties to their natural state, thereby ensuring habitat, water quality functions and historical significance
7) Develop guidelines for specific and variable uses of conservancy properties when needed. Rules need to be clear, and maintaining of property character
8) Identify areas for buffer establishment and/or restoration

3.8 Shoreline and Shoreland

Shorelands provide value in terms of nutrient retention and filtration, but also play an important role in wildlife habitat. Research has shown that coarse woody habitat, often within natural or undeveloped shorelines, provides many ecosystem benefits in a lake. Coarse woody habitat describes habitat consisting of trees, limbs, branches, roots and wood fragments at least four inches in diameter that occur along the shoreline. Coarse woody habitat provides shoreland erosion control, a carbon source for the lake, prevents suspension of sediments, provides a surface for algal growth which is important for aquatic macroinvertebrates, and perhaps most importantly, provides crucial habitat for fish. Shoreline development, land conversion, cleared and mowed vegetation, pier development and removal of trees and logs have collectively removed important shore structure that would otherwise support habitat for fish and wildlife, increase biodiversity, and improve water quality and general aesthetics.

Carstens Lake shoreline development began sometime after the mid-1960s. Shoreline mowing and maintenance as lawn decreases water quality by increased inputs of phosphorus and sediments into the lake. Removal of native plants and deadwood from shallow, near-shore areas, most often to allow for boating and swimming, negatively impacts habitat for fish, mammals, birds, insects and amphibians, while leaving the bottom and shoreline sediments vulnerable to wave actions. The protection of biologically and structurally diverse shoreline areas and adjacent wetland/upland interface is critical for sustaining a healthy lake.

Healthy natural and native submergent, emergent and floating leaf plant communities are low in diversity and may be impaired by non-native species. Beds of aquatic vegetation are important for spawning, habitat and shelter for many species of fish, amphibians, turtles, birds, mammals, and macroinvertebrates, and require cautious management, including protection from motorized boat traffic and other recreation usage that may damage the habitat. These areas should be priorities for protection from AIS, especially Eurasian water milfoil and *Phragmites*, which can degrade the habitat and lead to a loss of biodiversity. Continued development pressure on the lake shoreline is another potential challenge facing Carstens Lake shoreline habitat.

Objectives for Shorelines and Shore Land

1) Preserve natural views
2) Preserve and restore structurally complex natural shorelines
3) Maintain and enhance connections between open water, wetland, and natural upland habitats

Strategy for Shorelines and Shore Land

1) Encourage "no motor, no wake" zones in and around sensitive shallow water habitats.
2) Habitat protection ordinances and education and outreach tools should be employed where appropriate.
3) Encourage coarse woody habitat along the undeveloped portions of the shoreline.
4) Enhance shoreland with additions of submergent, emergent, and floating-leaf plants within the lake itself.
5) Employ zoning when possible to preserve remaining natural lakeshore

3.9 Education and Outreach

There are numerous regional education and outreach organizations, comprised of environmental advocacy groups, associations and friends groups, which citizens can utilize for information about water quality. These groups have provided consistent leadership and cooperation with the lake community. Newsletters, community events and educational forums are focused on the fishery, recreation opportunities, ecology, aquatic invasive species, natural history, land stewardship, and more.

Objectives for Education and Outreach (combined with County-wide efforts)

1) Improve the public's understanding of lakes, streams, watersheds, and how these resources impact community and quality of life
2) Improve communications between partners to leverage and expand outreach efforts

Strategy for Education and Outreach (combined with County-wide efforts)

1) Continue to publish lake and watershed trends (newsletters, web sites, radio, newspapers)
2) Create educational material or packets of information regarding new or existing educational programs.
3) Work with partners to continue watershed education opportunities to the public. Topics may include surface water management, nutrient management, nitrate screening and conservation practices.

4) Per Manitowoc County Soils and Water Dept 10-Year Land and Water Plan, new education and outreach programs shall focus on: Improving groundwater and surface water quality, creating awareness of conservation stewardship efforts being implemented, County Ordinance requirements, State Standards for compliance of Farmland Preservation Program income tax credit, incentives and cost share availability for installation of conservation practices and many other environmental topics to enhance the quality of our natural resources.

3.10 Management Capacity, Objectives and Strategies

Local leadership from the County and local nonprofits as been strong and the engagement by all partners has been exemplary. A challenge for the lake community and its leadership is maintenance of management capacity. Proper attention to management capacity involves all partners, including the general public.

Because multiple interests are involved, clarity of responsibility is critical. There are many stakeholders in addition to the principle management units such the County, NRCS and WDNR. The challenge for the partnership will be to act on, and promote, continued integration, while improving the public's understanding about management structure.

All individuals on a team must be equipped with good working skills to effectively represent themselves and their respective management unit. Working on cooperative projects and being on a team with common objectives requires knowledge of human nature, consensus building, and team process. Building these skills is not an easy task. Advanced learning for maintaining a long range strong partnership is necessary.

Objectives for Management Capacity

1) Improve public understanding of management organization in the watershed and lake
2) Maintain and enhance the partnerships among principle and secondary management unit

Strategy for Management Capacity

1) Provide a clear description of management unit responsibilities and interaction with partners. This can be partially completed via existing Education and Outreach vehicles including partner's newsletters and annual meetings. Develop professional publications which list all the organizations, what they do, how they do it, and how they work together
2) Evaluate priorities on annual basis and make adjustments
3) Create a timeline chart with management accomplishments. This should include significant milestones for all local partner organizations.

3.11 Climate Change

Climate change is a controversial and highly charged topic. When developing long-term planning goals and practices, an approach that takes into account potential future conditions based on the best available science is recommended. Climate trends indicate increasing average temperatures, greater frequency and magnitude of flooding, and longer droughts. Some considerations for Carstens Lake and the region are outlined below.

- **Temperature Increase:** As the average seasonal temperature increases, duration of lake ice cover will be reduced. Fewer days of ice on the lake will allow for greater light penetration into the water. Instead of reflecting light off the ice, it will be absorbed by the water, which will increase the heat the lake absorbs. As a result, water temperature increases, which impacts the fishery. Additionally, intensity and duration of light penetration for plant growth will affect timing, quantity and quality of the lake plants.
- **Increased Precipitation:** As average temperatures increase, the atmosphere can hold more water as vapor, resulting in more frequent and intensive rainfall. Increased intensity of storm events has already been observed in recent years in Wisconsin. Heavy rainfall events result in large pulses of water carrying increased sediment loads which enter the lake in a short period of time. Studies suggest that heavy precipitation events are responsible for the majority of phosphorus entering lakes (Motew et al, 2017; Carpenter et al, 2014). Increasing frequency of heavy rainfall is expected to mobilize more soil phosphorus from the watershed. Planning for the next several decades mayhave to take into account longer growing seasons, greater volumes of runoff, and increasing frequency of 10-year, 100-year or greater flood events.

For further information on climate change in Wisconsin refer to the website "Wisconsin Initiative on Climate Change Impacts (UW WI, 2010): http://www.wicci.wisc.edu/

Objectives for Climate Change

1) Manage lake to counterbalance negatives from climate change
2) Promote ecological resiliency
3) Promote understanding of the issue locally
4) Integrate anticipated climate issues into lake planning

Strategy for Climate Change

1) Promote innovation in existing and future BMP construction
2) Enhance the Education and Outreach program to include local understanding of climate change effects
3) Encourage robust, native and diverse wetland, riparian, and aquatic plant communities within the entire watershed
4) Ensure future watershed development meets existing design standards or better, in anticipation of climate change induced flooding in the watershed. This would pertain to storm water structures, agriculture and new development.

4.0 FUNDING SOURCES

The following funding source should be consulted for implementing the lake and watershed improvement strategies outline above.

Funding sources
October 26, 2017

Wisconsin Department of Agricultural, Trade, and Consumer Protection (DATCP)

Soil and Water Resource Management Cost-Share Funds: DATCP allocates cost-share dollars for conservation practices in Manitowoc County. The Soil and Water Conservation Department administers cost sharing for applicants and helps farmers implement conservation practices.

Conservation Reserve Enhancement Program (CREP): The Soil and Water Conservation Department administers state incentives and cost share funds. The Conservation Reserve Enhancement Program (CREP) is an offshoot of the Conservation Reserve Program, the country's largest private-land conservation program. CREP targets high-priority conservation issues identified by local, state or tribal governments or non-governmental organizations. In exchange for removing environmentally sensitive land from production and introducing conservation practices, farmers, ranchers and agricultural land owners are paid an annual rental rate, along with other federal and state incentives as applicable per each CREP agreement. Participation is voluntary and the contract period is typically 10-15 years. Typical practices include filter strips and riparian buffers.

Wisconsin Department of Natural Resources

Targeted Runoff Management Grant: The runoff management grant provides funding, and authorizes cost-share reimbursement for practices installed to cure a notice of discharge violation. The Soil and Water Conservation Department administers grants and provides technical assistance under the runoff management grant program.

Well Abandonment: Financial assistance for individuals to properly abandon unused private wells. Unused wells are a direct line for contamination into clean ground water.

Wisconsin Wetland Conservation Trust in Lieu Fee Mitigation Program (WWCT): Land trusts, conservation groups, government organizations, or Wisconsin landowners may apply for a WWCT grant to preserve, enhance, and restore wetland resources in Wisconsin.

Knowles-Nelson Stewardship Program (K-N): Funds are provided to local units of government and nonprofit conservation organizations for land acquisition and recreational development statewide.

Surface Water Grants:

- AIS Prevention and Control Grants - share the costs of aquatic invasive species education programs that teach about the threats posed by invasive species and how to prevent and control them. These grants also help with projects that prevent new introductions, control existing populations, and restore habitat.
- Lake Protection Grants - assist eligible applicants with implementation of lake protection and restoration projects that protect or improve water quality, habitat or the elements of lake ecosystems.
- River Protection Grants – provide assistance in the formation of river management organizations and provides support and guidance to local organizations that are interested in helping to manage and protect rivers, particularly where resources and organizational capabilities may be limited.

United States Fish and Wildlife Service

Partners for Wildlife Program: The U.S. Fish and Wildlife Services provides technical and financial assistance to private landowners with a desire to provide suitable habitat for wildlife on their property.

Coastal Program: Provide funds for restoring and protecting fish and wildlife habitat on public and privately-owned lands.

United States Department of Agriculture: Natural Resource Conservation Service (NRCS)

Conservation Technical Assistance: NRCS assists land-users, communities, units of state and local government, and other Federal agencies in planning and implementing conservation systems. These conservation systems reduce erosion, improve soil and water quality, improve and conserve wetlands, enhance fish and wildlife habitat, improve air quality, improve pasture and range condition, reduce upstream flooding, and improve woodlands. NRCS provides conservation planning to landowners.

Environmental Quality Incentive Program (EQIP): EQIP provides technical and financial help to farm and forest landowners for conservation practices that protect soil and water quality. Grassed waterways, stream fencing, critical area planting, manure management systems including storage structures and barnyard runoff protection, and many other conservation practices are eligible.

Great Lakes Restoration Initiative (EQIP-GLRI): To improve the health of the Great Lakes, the Natural Resource Conservation Service provides financial and technical resources to Manitowoc County landowners to improve water quality in the region. Through this Initiative, the Natural Resource Conservation Service focuses on helping farmers implement conservation practices that reduce erosion, improve water quality, and maintain agricultural productivity in selected watersheds.

Conservation Stewardship Program (CSP): CSP is a voluntary conservation program that encourages producers to continue to improve and maintain existing conservation activities as well as undertake additional conservation activities.

Conservation Reserve Program (CRP): CRP can reduce erosion, increase wildlife habitat, improve water quality, and increase forestland. Landowners set aside cropland with annual rental payments based on a bid. Tree planting, wildlife ponds, grass cover, and other environmental practices are eligible practices.

Conservation Reserve Enhancement Program (CREP): The Conservation Reserve Enhancement Program is an offshoot of the Conservation Reserve Program, the country's largest private-land conservation program. CREP targets high-priority conservation issues identified by local, state or tribal governments or non-governmental organizations. In exchange for removing environmentally sensitive land from production and introducing conservation practices, land owners are paid an annual rental rate, along with other federal and state incentives as applicable per each CREP agreement. Participation is voluntary and the contract period is typically 10-15 years. Typical practices include filter strips and riparian buffers.

Agricultural Conservation Easement Program (ACEP): ACEP provides financial and technical assistance to help conserve agricultural lands and restore wetlands. Under the Agricultural Land Easements component, the Natural Resource Conservation Service helps state and local governments, Native American tribes, and non-governmental organizations protect working agricultural lands and limit non-agricultural uses of the land. Under the Wetlands Reserve Easements component, NRCS helps to restore, protect and enhance wetlands that have been altered for agriculture.

5.0 GRANT-FUNDED RECOMMENDATIONS

Pursuant to WDNR guidelines, this Plan must specify which actions are to be paid for with WDNR grant funds. The WDNR Lake Management Planning Grant associated with this Plan (#LPL163117) shall be used to implement the recommendations outlined in Appendix B and illustrated on Figure 10.

The proposed actions included within the Plan will be subject to ongoing monitoring and evaluation against objectives and target achievements. Investments of time, resources and effort will be evaluated for success, and may be reallocated as part of an adaptive management approach. Modifications of approach, based on new data or changing understandings of the underlying systems, will be integrated as the Project proceeds.

6.0 REFERENCES

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Appendix A – FIGURES

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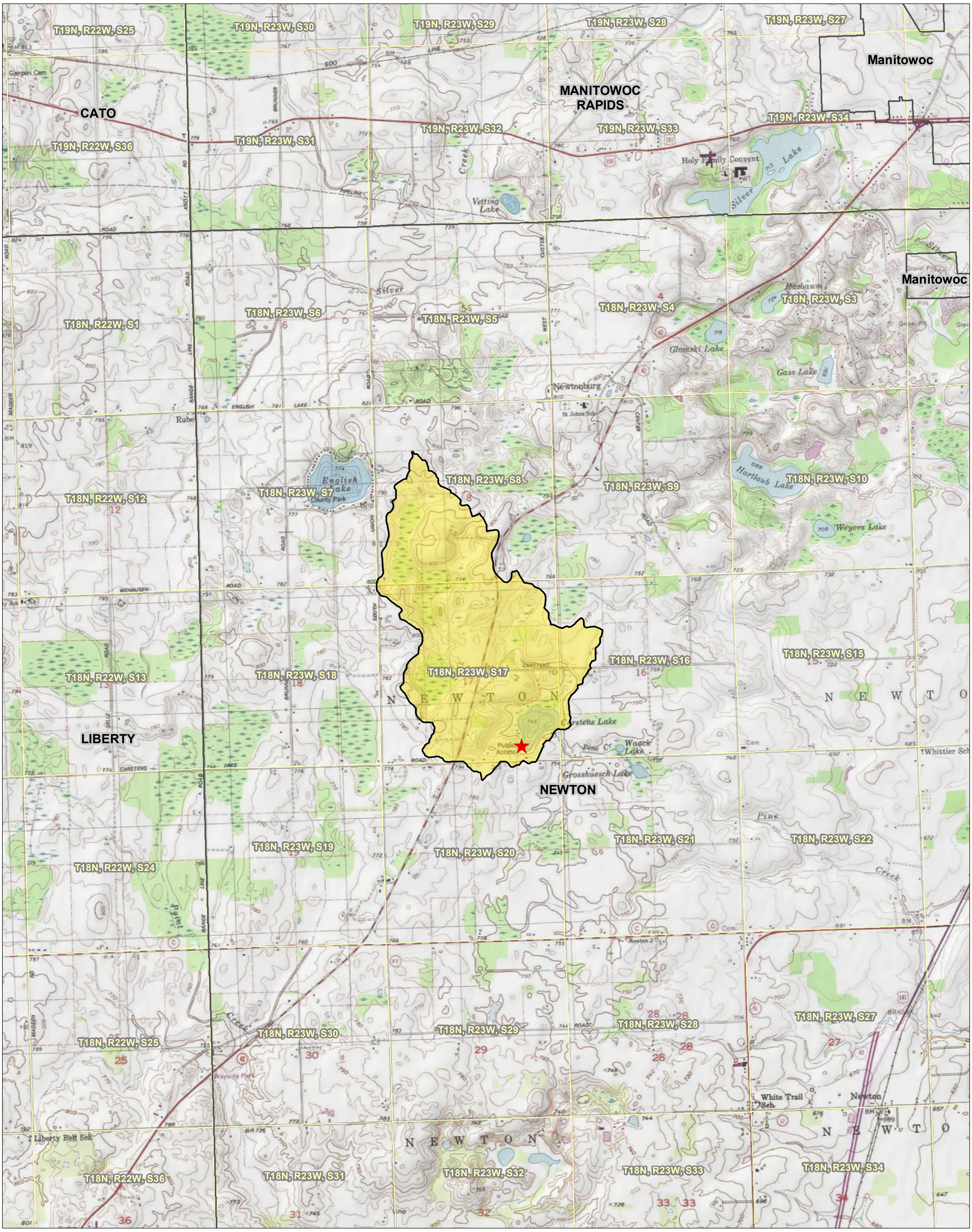

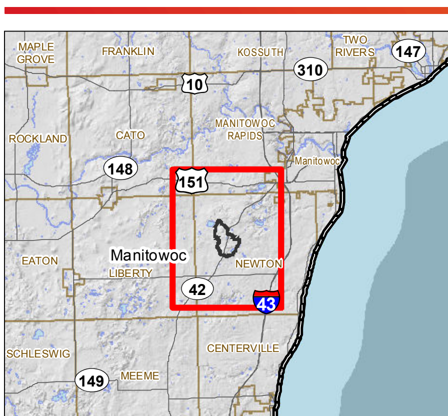

Legend

Carstens Lake Watershed (767.04 acres)

Public Access Point

Figure No.

1 **DRAFT**

Title

Project Location Overview

Client/Project

Lakeshore Natural Resource Partnership
Carstens Lake Watershed

Project Location
T18N, R23E, S7, 8, 16-18, 20,
T. of Newton, Manitowoc Co., WI

193705103
Prepared by JM on 2017-10-24
Technical Review by SF on 2017-10-25
Independent Review by XXX on 2017-XX-XX

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3. Background: USGS 7.5' Topographic Quadrangles

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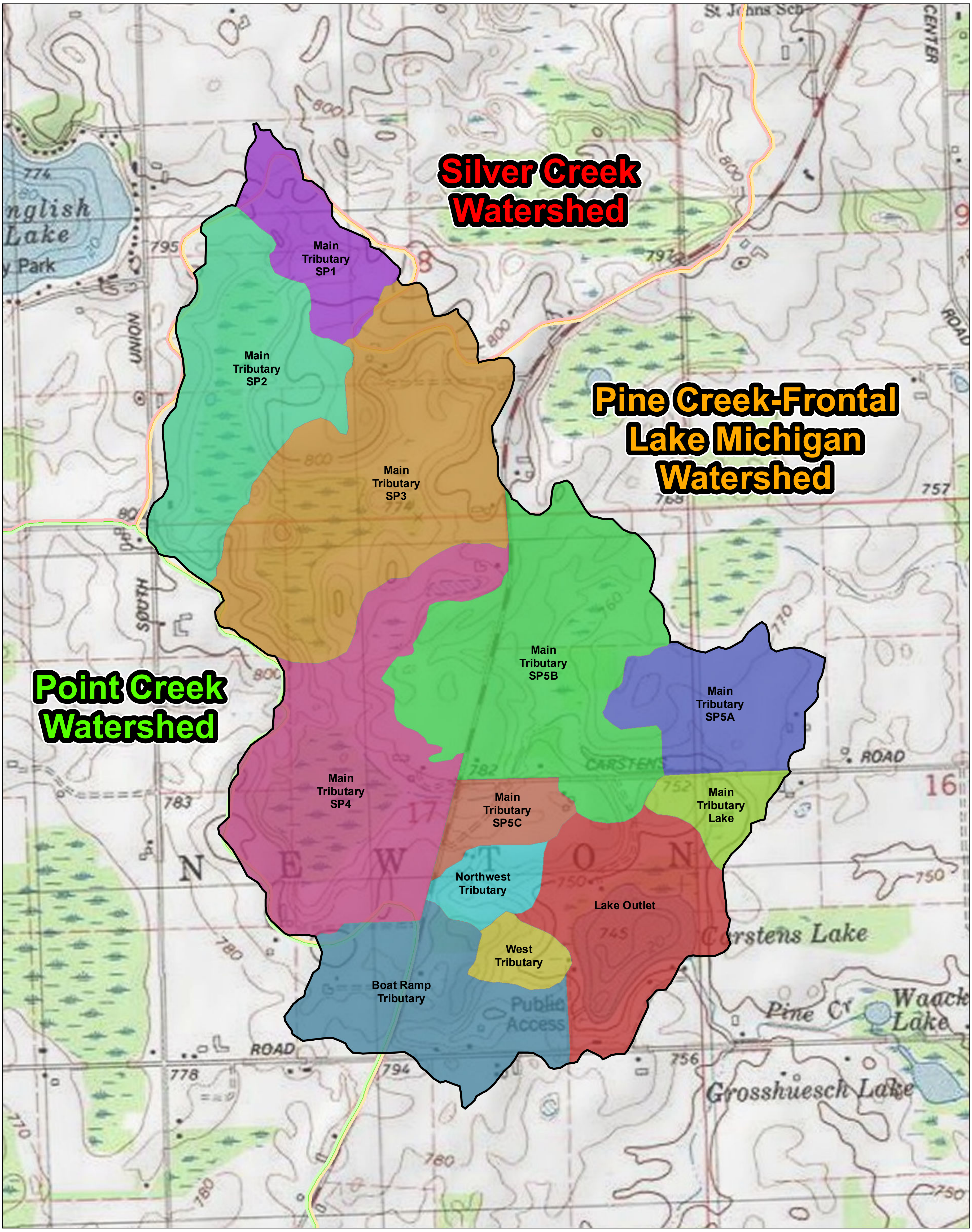

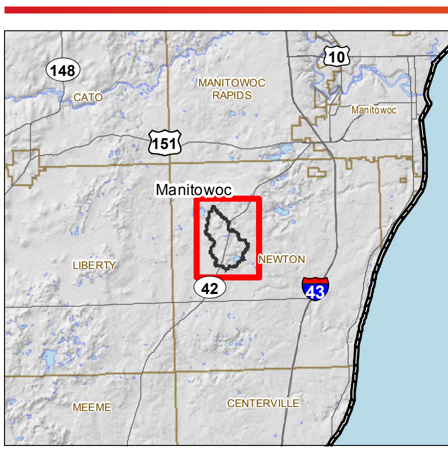

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2. Data Sources Include: Stantec, WisDOT, WDNR, USGS
3. Background: USGS 7.5' Topographic Quadrangles

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Legend

Carstens Lake Watershed (767.04 acres)

Sub-Basin
- Boat Ramp Tributary
- Lake Outlet
- Main Tributary - Lake
- Main Tributary - SP1
- Main Tributary - SP2
- Main Tributary - SP3
- Main Tributary - SP4
- Main Tributary - SP5A
- Main Tributary - SP5B
- Main Tributary - SP5C
- Northwest Tributary
- West Tributary

HUC-12 Watershed
- Pine Creek-Frontal Lake Michigan Watershed
- Point Creek Watershed
- Silver Creek Watershed

Figure No.
6

DRAFT

Title
Subwatershed Boundaries

Client/Project
Lakeshore Natural Resource Partnership
Carstens Lake Watershed

Project Location
T18N, R23E, S7, 8, 16-18, 20,
T. of Newton, Manitowoc Co., WI

193705103
Prepared by JM on 2017-10-24
Technical Review by XXX on 2017-XX-XX
Independent Review by XXX on 2017-XX-XX

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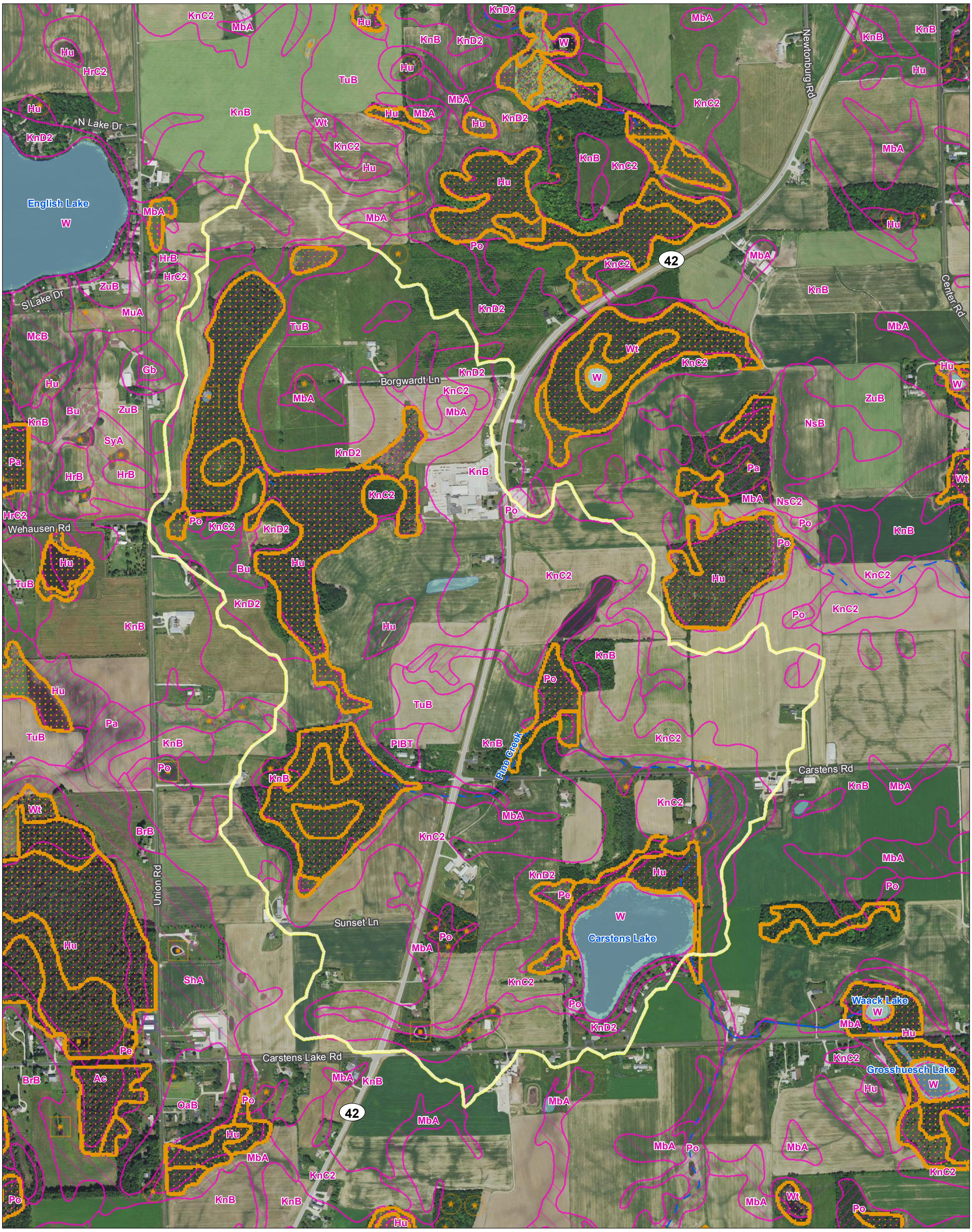

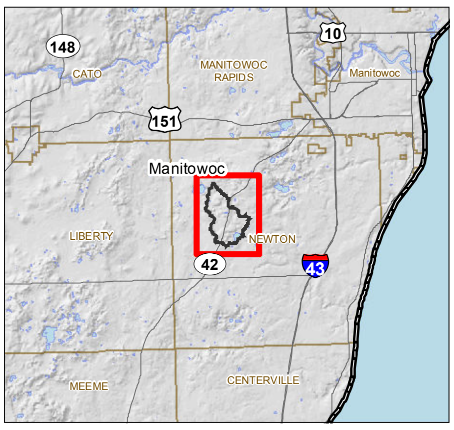

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Carstens Lake Watershed (767.04 acres)

WWI Wetland Class Points
- Excavated Pond
- Dammed Pond
- Wetland Too Small To Delineate
- Filled Points

WWI Wetland Class Areas
- Wetland
- Filled Areas

NRCS Soil Survey Data
Hydric Ratings
- Predominantly Hydric Soil
- Partially Hydric Soil
- Non-Hydric Soil

DNR 24k Hydrography
- Perennial Stream
- Intermittent Stream
- Waterbody

Figure No.
8

DRAFT

Title
Environmental Features

Client/Project
Lakeshore Natural Resource Partnership
Carstens Lake Watershed

Project Location
T18N, R23E, S7, 8, 16-18, 20,
T. of Newton, Manitowoc Co., WI

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Prepared by JM on 2017-10-24
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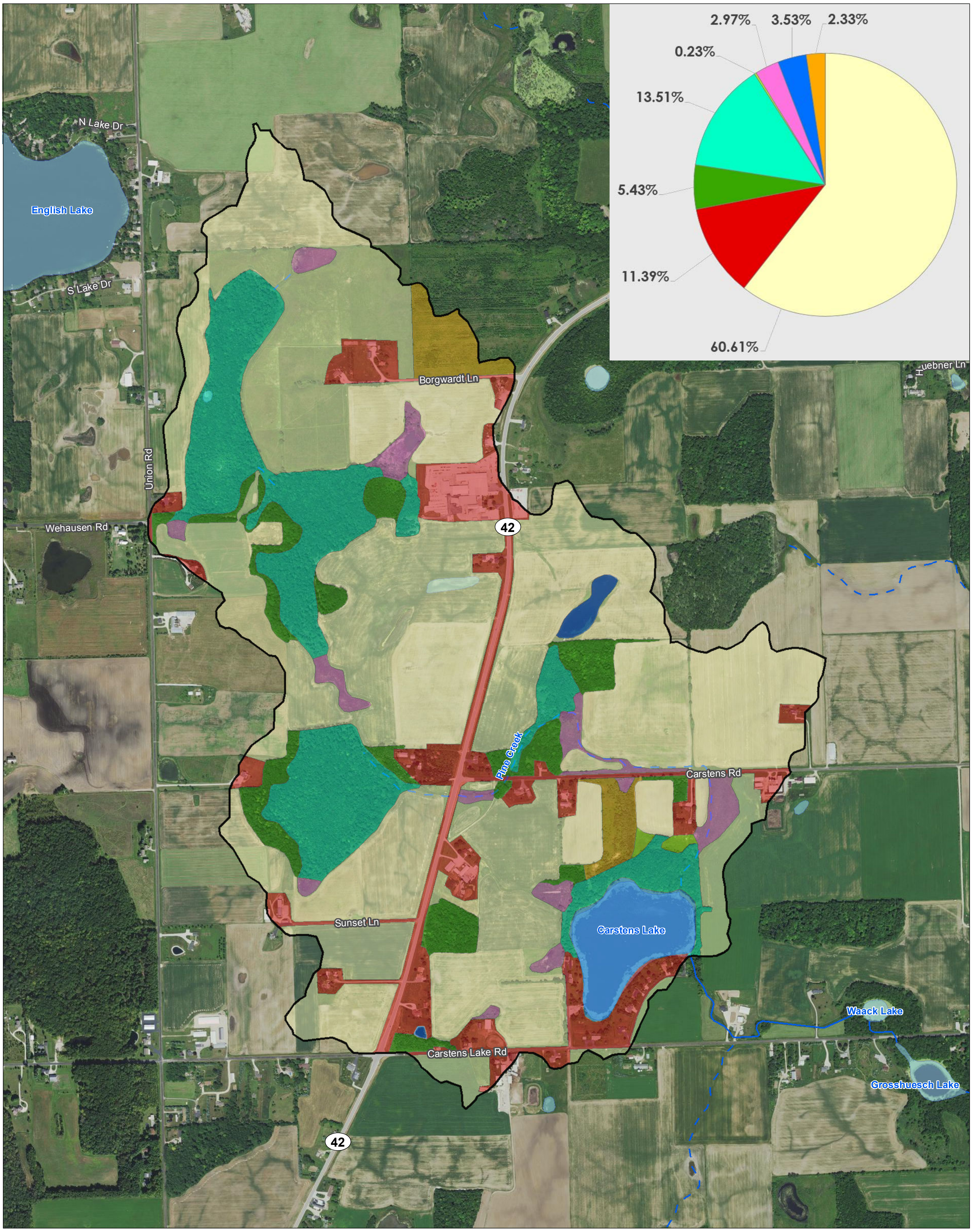

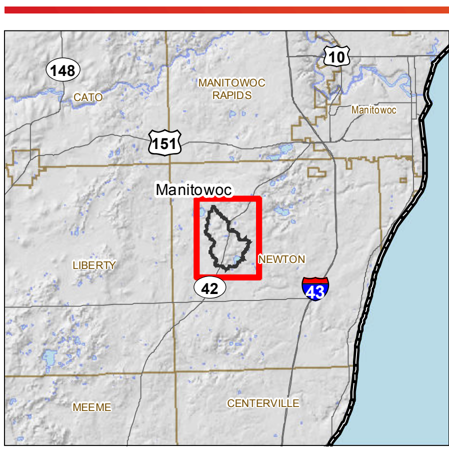

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Carstens Lake Watershed (767.04 acres)

Land Cover

- Agriculture (464.94 acres)
- Developed (87.33 acres)
- Forest (41.66 acres)
- Forested Wetland (103.65 acres)
- Grassland (1.73 acres)
- Herbaceous Wetland (22.80 acres)
- Open Water (27.09 acres)
- Shrubland (17.84 acres)

DNR 24k Hydrography

- Perennial Stream
- Intermittent Stream
- Waterbody

Figure No.

9 **DRAFT**

Title

Land Cover

Client/Project

Lakeshore Natural Resource Partnership
Carstens Lake Watershed

Project Location
T18N, R23E, S7, 8, 16-18, 20,
T. of Newton, Manitowoc Co., WI

193705103
Prepared by JM on 2017-10-24
Technical Review by XXX on 2017-XX-XX
Independent Review by XXX on 2017-XX-XX

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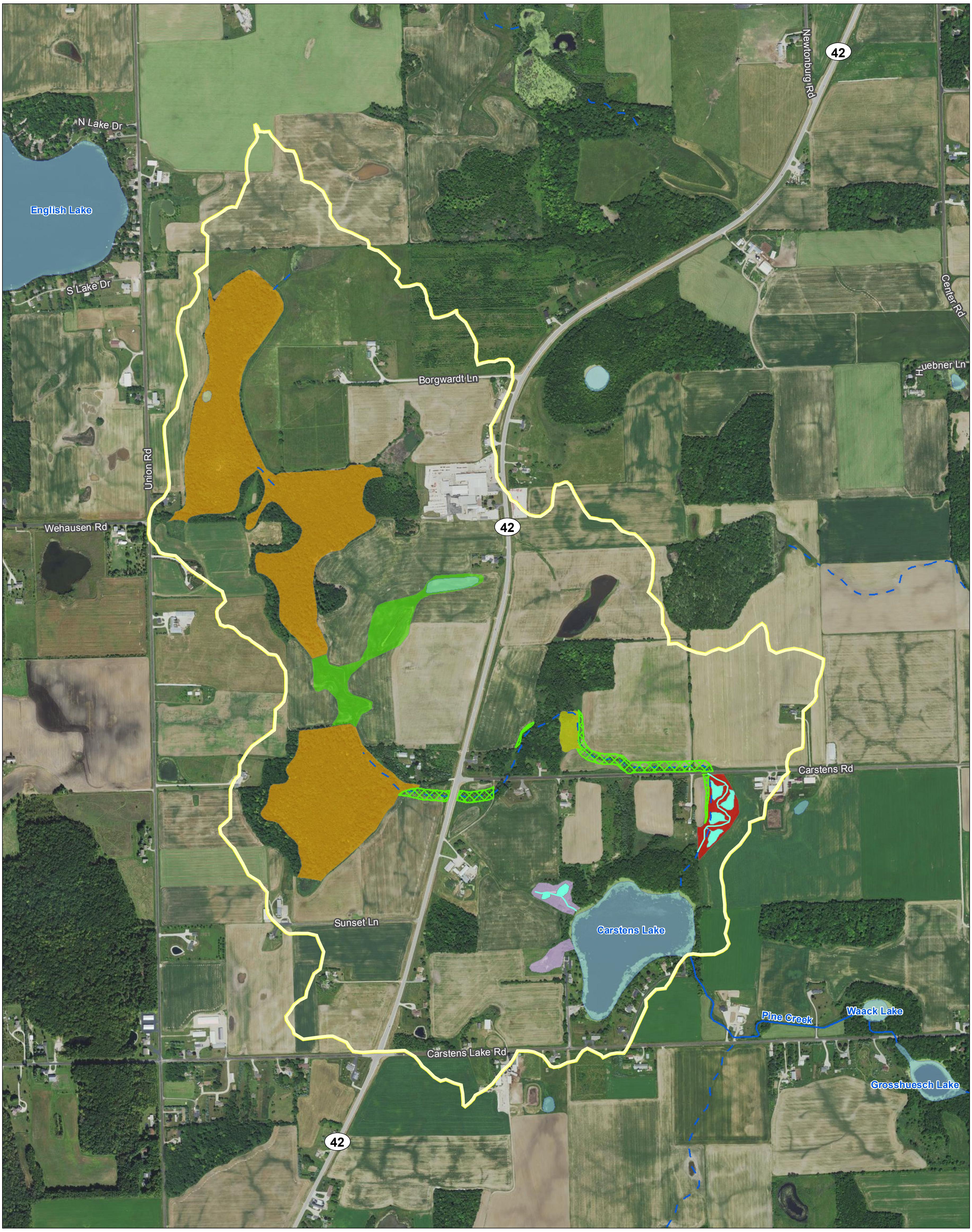

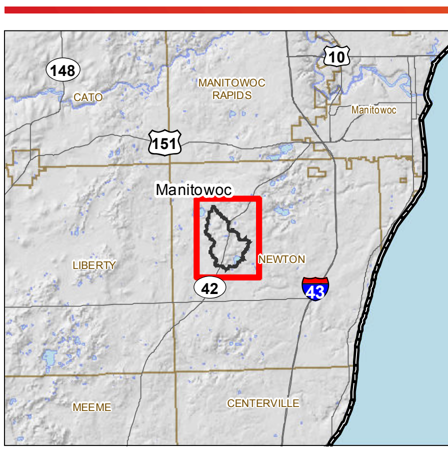

Legend

- Carstens Lake Watershed (767.04 acres)
- Stream Realignment
- 100ft Riparian Buffer
- Sedimentation Basin
- Spawning Enhancement/Sediment Basin
- Spawning Enhancement
- Spawning Ponds/Shallow Marsh
- Wetland Preservation Measures
- Wetland Restoration Measures

DNR 24k Hydrography

- Perennial Stream
- Intermittent Stream
- Waterbody

Figure No.
10

DRAFT

Title
Recommended Conservation Practices

Client/Project
Lakeshore Natural Resource Partnership
Carstens Lake Watershed

Project Location
T18N, R23E, S7, 8, 16-18, 20,
T. of Newton, Manitowoc Co., WI

193705103
Prepared by JM on 2017-10-24
Technical Review by XXX on 2017-XX-XX
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3. Orthophotography: 2015 NAIP

Stantec

Appendix B YEAR 1 ACTION ITEMS

Year 1 Action Items (Figure 10)				
Category	**Management Strategy**	**Lead Partner**	**Timeline**	**Funding Source**
Watershed	Identify working committee that meets quarterly to assess progress, make changes, improvements, or further actions. A one-page summary at year-end should describe the year's relevant events and decisions. Committee shall oversee, manage or be made aware of all action items, watershed eudcation and outreach activities, tributary and lake monitoring efforts, aquatic plant surveys, Clean Boats Clean Water Program (CBCW) activites, preservation-related discussions and BMPS implemented.	Representatives recommended from County, laksehore landowner, watershed landwoner (preferably farmer), nonprofit	Meets quarterly	??
Fishery/Watershed	Spawning Improvements/Sedimentation Basin - Enhance existing wetland connections to the lake to provide additional spawning and rearing habitat for fish as well as trapping sediment. Enhancements include: stream realignments, invasive species removal, re-establish native plant communities, create off-channel ponds and woody debris additions.	??	Apply for grant by February 1, 2018	WDNR Surface Water Grant - Lake Protection, FWS
Natural Communities and Land Conservation	Land Preservation - work with partners and property owners to preserve and protect sensitive natural areas.	Glacial Lake Conservancy	2018	WDNR, K-N Stewardship
Watershed	Integrate watershed objectives with all current and proposed water quality strategies, administered or under the guidance of The Soil and Water Conservation Department. Priority practices shall include: manure storage facilities, barnyard runoff, grasses waterways, wetland restoration and sediment retention basins, conservation buffers, conservation easements, nutrient management plans, conservation crop rotations, vegetated treatment areas, milkhouse waste, cover crops, reduced tillage and subsurface drainage.	Manitowoc County Soil and Water Conservation Department.	On-going	NRCS, County, DATCP
Lake Habitat and Plants	Perform aquatic plant inventory in 2018 and evaluate feasibility of control efforts for nuisance aquatic plants, such as mechanical removal (hand-pulling, raking and hand-cutting), bottom screens, water level manipulations, mechanical harvesting, herbicide treatment or biological controls. Appraise feasibility for Eurasian water milfoil and curly-leaf pondweed control on lake.	MCLA?	Summer 2018	WDNR Surface Water Grant - Lake Planning?